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16. ABSTRACT

The report covers the resource and potential reclamation evaluation of the Collom Gulch study area located in northwestern Colorado. The purpose of the report is to present baseline data on the climate, physiography, geology, coal resources, soil, overburden, hydrology, vegetation, wildlife, and cultural resources of the area. Recommendations for successfully reclaiming the poststrip-mined areas are also included in the report.

Five drill holes were drilled to a combined depth of 1,458 feet for the geological and overburden investigations. Samples of the cores were used in greenhouse, weathering, and chemical tests to determine their suitability as plant growth media. A land classification survey was made to determine the quality and quantity of suitable soil for revegetation. The vegetation was mapped by vegetative soil units to determine the present and potential vegetation. The present hydrology was studied and its potential effects on mining discussed. The wildlife and cultural resources were studied and the probable impact of strip-mining on them was noted. The climate and its effect on potential reclamation was studied. The potential reclamation problems and recommendations for practices and procedures to insure successful revegetation were discussed.

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Attachment B
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Appendix G--Surface Water Hydrology (Continued)

Attachment B (Continued)
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CHAPTER I

INTRODUCTION

This resource and potential reclamation evaluation is prepared for the Collom Gulch study site of northwestern Colorado as shown on the map on the following page (Figure 1). This presentation of the available data was gathered by the various Federal agencies involved in the Federal Coal Management Program of the Department of the Interior. The purpose of this program is to develop energy resources to satisfy the needs of society and to ensure the nondegradation of the air, water, soil, vegetation, natural landscape, and wildlife of the affected areas. The recent energy crisis has focused attention on the importance of developing and conserving the abundant and high quality bituminous coal resources of the Western States.

The Department of the Interior and, principally, the Bureau of Land Management and Office of Surface Mining, working with the State of Colorado Mined Land Reclamation Board, have the responsibility to provide the overall management and guidance for acceptable reclamation of the lands subject to disturbance by resource development.

Purpose

The purpose of the study is to assure and preserve adequate baseline data for choosing optimum reclamation and rehabilitation objectives and for establishing appropriate data and interpretations for preparation of lease stipulations through site-specific preplanning of surface mining and reclamation.

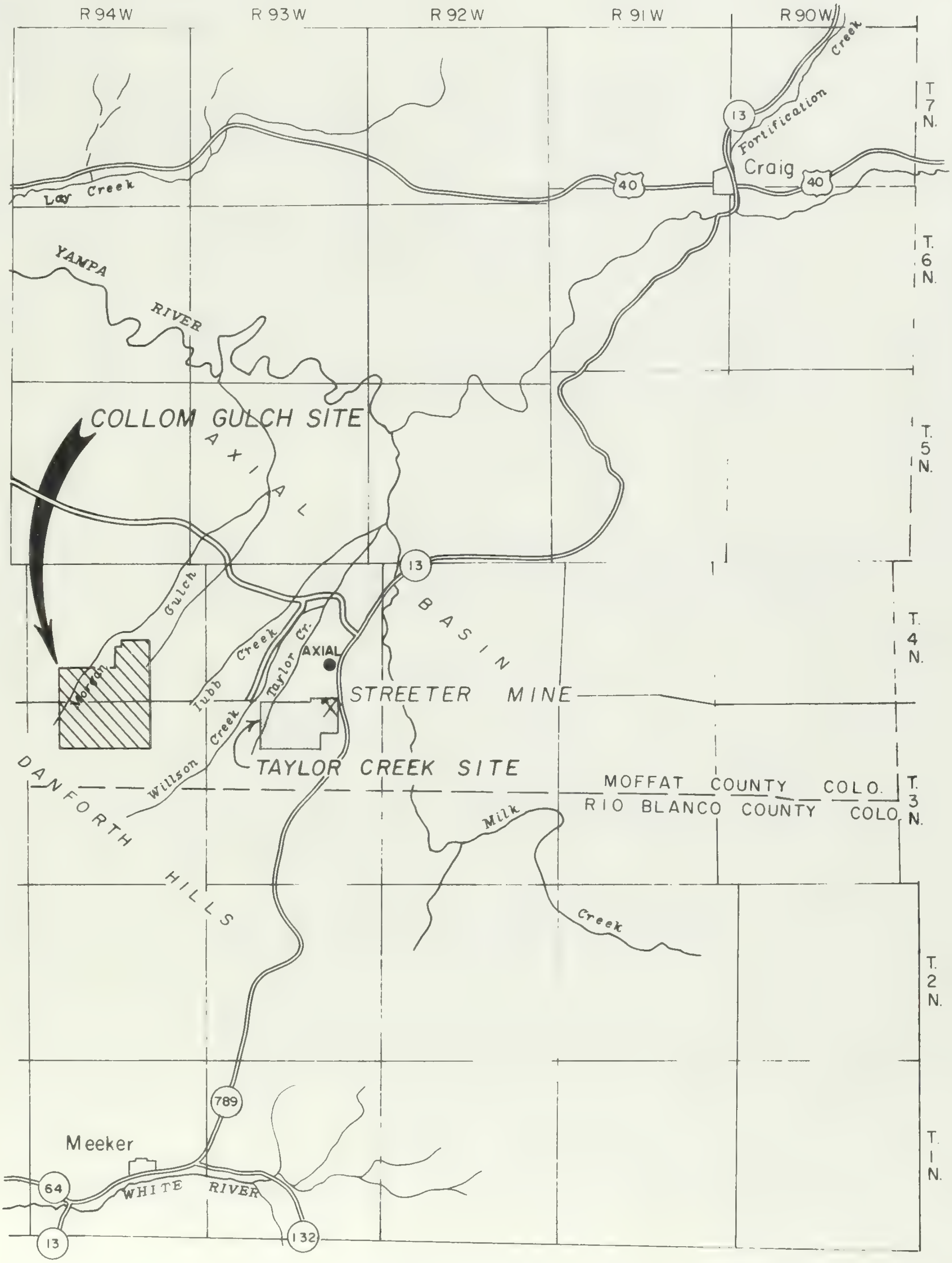
Objectives

1. To analyze and quantify environmental impacts from surface mining of coal minerals in the Collom Gulch, Colo. area.

2. To provide resource and potential impact information to the leasing site selection procedures as set forth by the Secretary of the Interior.

3. To provide environmental resource information needed to implement effective reclamation and rehabilitation programs and for the development of meaningful lease stipulations as required by the mined land reclamation program.

4. To provide resource and environmental impact information to support State and local regional development and land use planning efforts.



COLLOM GULCH SITE
GENERAL LOCATION
FIGURE 1

5. To determine the present and potential capability of the surface soil and subsurface resources to produce and maintain vegetation on known energy fuel deposits.

6. To provide physical and chemical data from which realistic stipulations may be prepared for energy mineral explorations, mining, and reclamation plans.

7. To provide data needed in the preparation of environmental impact statements, environmental analysis records, and to aid in the review of mining and reclamation plans for potential coal leasing activities in the vicinity of the study area.

Authority

Public Land Administration Act of July 14, 1969 (74 Stat. 506), Federal Land Policy and Management Act of 1976 (Public Law 94-579), and Surface Mining Control and Reclamation Act of 1977 (Public Law 95-87).

Responsibility

Bureau of Land Management

1. Select reclamation study site, with advice from the United States Geological Survey, for the investigation of vegetation, soil, geological structure, surface water, ground water, and coal resources.

2. Provide access to study site; prepare and provide for environment clearances required to conduct the study.

3. Prepare, coordinate, issue, and monitor the execution of work orders.

4. Identify probable postmining land use and present land use.

5. Prepare inputs to the report covering wildlife, cultural and visual resources, and summary of regulations on mineland reclamation.

6. Provide technical support, guidance, and flag dates to the other cooperating agencies.

7. Distribute technical data, reports, and reclamation and rehabilitation recommendations to the Bureau of Land Management field offices.

Bureau of Reclamation

1. Conduct land studies, including land classification for determining suitability of soil and bedrock material, soil inventory, and laboratory characterization program.

2. Conduct core drilling operations for procurement of core samples used for the characterization and analysis of the geologic overburden materials.

3. Map surface geology.

4. Prepare geologic logs on drill holes.

5. Collect and submit coal samples to the Geological Survey.

6. Where required and as needed install casing in drill holes selected for ground water observation wells.

7. Characterize and interpret data available on soils and overburden materials as well as the substrata immediately below the coal resource in relation to reclamation potential and revegetation.

8. Advise and recommend suitable plant species for use in areas to be reclaimed.

9. Recommend reclamation techniques.

10. Perform slope stability investigation.

11. Coordinate, assemble, and print the final report.

U.S. Geological Survey

1. Assess reclamation potential based on water supply.

2. Prepare sediment yield data.

3. Prepare erodibility data.

4. Determine rainfall-runoff relationships and analyze surface and subsurface waters for chemical quality.

5. Tabulate coal resource data, including resource estimates and analytical results.

6. Evaluate effects of mining on the area hydrology and downstream areas.

Location and Setting

The Collom Gulch study site is located in Moffat County in northwestern Colorado. It is approximately 40 miles south and west of Craig, Colo., the county seat. The study area comprises approximately 5,455 acres in all or parts of 10 sections in Tps. 3 and 4 N., and R. 94 W.

The site lies approximately 3 miles south, off a main county road, and is reached via a private ranch road up Morgan Gulch, 6 miles west of Axial, Colo.

Historical Perspective

Early explorers found northwestern Colorado, including the Axial Basin, occupied by the Ute Indians. The first historic exploration of the area was by the Dominguez-Escalante Expedition in 1776. This expedition entered northwestern Colorado, but only as far north as the White River Valley south of the Danforth Hills and Axial Basin.

Later, European explorers were initially involved in the fur trapping industry. In the late 1850's settlers began to move into the area, and in 1868 the White River Indian Agency was established to "educate and civilize" the Ute Indians. The Meeker Massacre occurred at the White River Agency in September 1879; the Indians were removed from northwestern Colorado; and the area was opened for homesteading. Dry-farming, cattle, and sheep grazing operations were quickly established with homesteads set up along perennial streams.

The coal resources of this area were noted early during its settlement. There are evidences of old mines throughout the study site with one of importance located along Collom Gulch in sec. 3, T. 3 N., R. 94 W. At the present no coal is mined in the study area.

Land and Mineral Status

Most of the land within the boundaries of the study site are in private ownership. Surface ownership at the time of the investigations consisted of private cattle and sheep ranch operations. Scattered throughout the private lands are parcels of public domain administered by the Bureau of Land Management.

Mineral rights at the site are controlled by the Federal Government and also administered by the Bureau of Land Management. Table 1 on the following page is a summary of land status by ownership.

Presently the surface lands in the Collom Gulch study site are owned by a private corporation, W. R. Grace and Company, and the Bureau of Land Management. Figure 2 on page 7 shows the land and mineral ownership for the site at the time of study.

Table 1
Land status[1/]

	Private land	Federal land	Total area
T. 3 N., R. 94 W.			
sec. 3	527.2	120.0	647.2
sec. 4	524.8	120.0	644.8
sec. 5	562.9	80.0	642.9
sec. 8	240.0	80.0	320.0
sec. 9	320.0	0	320.0
sec. 10	320.0	0	320.0
Subtotal	2,494.9	400.0	2,894.9
T. 3 N., R. 94 W.			
sec. 27	470.9	160.0	630.9
sec. 32	576.3	40.0	616.3
sec. 33	551.3	80.0	631.3
sec. 34	560.0	80.0	640.0
Subtotal	2,158.5	360.0	2,518.5
Total	4,653.4	760.0	5,413.4

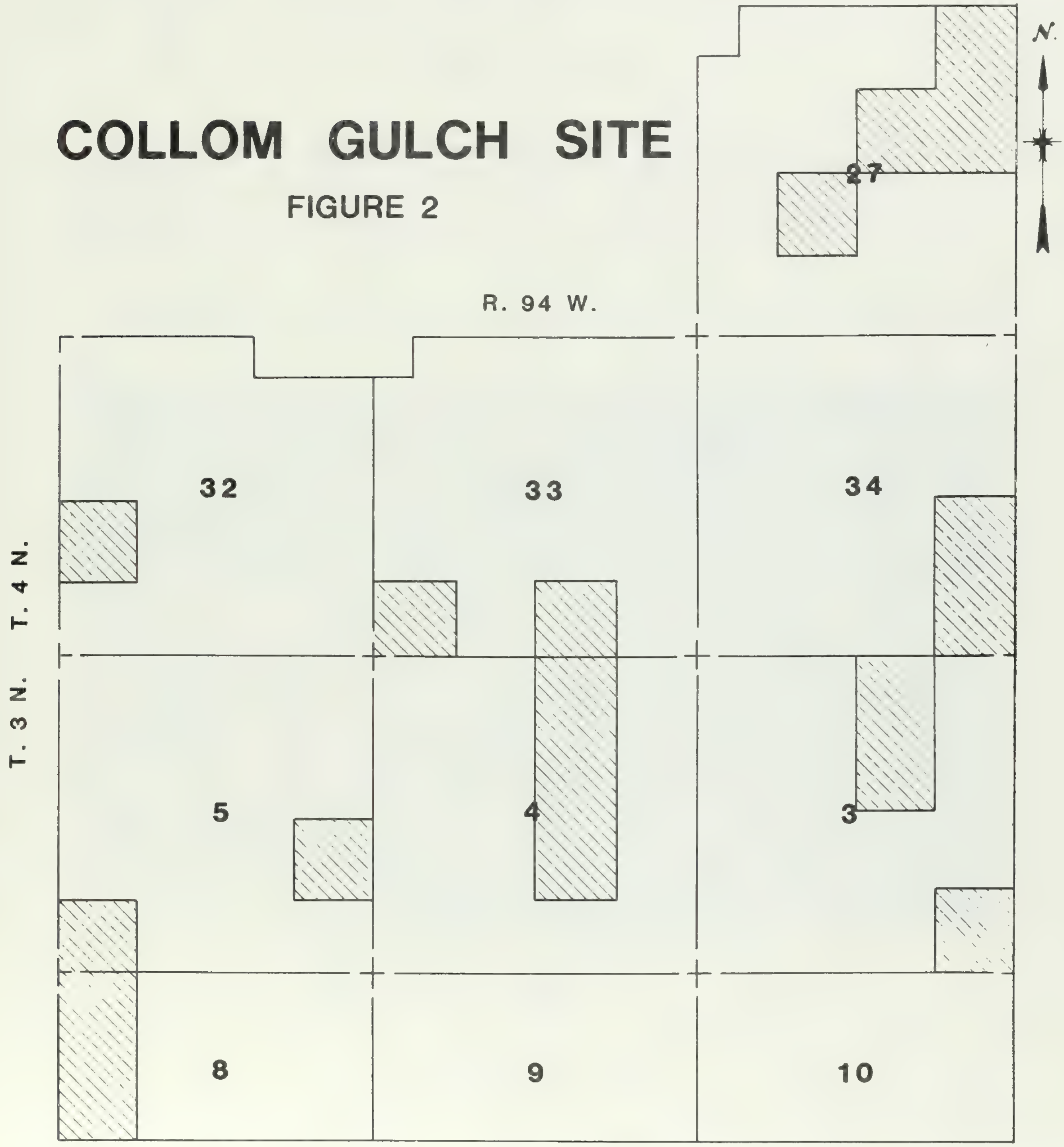
1/ Classified area by ownership (acres).

LAND AND MINERAL OWNERSHIP

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

COLLOM GULCH SITE

FIGURE 2



EXPLANATION

- - - - - - Federal Lands--Federal Minerals

- - - - - - Private Lands--Federal Minerals

CHAPTER II

PHYSICAL PROFILE

The Collom Gulch study site located in northwestern Colorado is approximately 6 miles west of Axial, Colo. Elevations at the site range from 6,700 to 8,300 feet above sea level. The major surface drainage is north from the Danforth Hills via Straight Gulch, Morgan Gulch, and Collom Gulch to the Yampa River.

The following photograph, taken in the study area, illustrates the local terrain.

View looking north over the broad, rolling ridgetops and long, narrow drainages of Morgan Creek.

Present Land Use

Lands of the Collom Gulch study site are part of the Danforth Hills and Axial Basin watershed area. Present land use for this area is principally rangeland utilized by both wildlife and livestock. Domestic livestock include both sheep and cattle. Important other land uses besides grazing include dryfarming (though not on the study site), hunting, and other winter and summer recreational uses. Livestock use on federally managed lands is permitted under grazing leases on approximately 760 acres administered by the Bureau of Land Management.

Wildlife uses include habitat for elk, deer, antelope, and small upland game species. Access is limited and restricted to much of the area due to private ownership, and fees for hunting have become common in the area.

Climate

The area has a continental climate characterized by wide annual variations in temperature and well defined seasons. The summers are mild with occasional hot spells accompanied by dry, moderate winds. The winters are cold with large amounts of dry, light, powdery snow.

July is the hottest month of the year with temperatures in the 80's in the day and mid-40's at night. January is the coldest month of the year with temperatures in the mid-30's in the day and about 5° F at night. The maximum and minimum mean temperatures are approximately 67° F in July and 18° F in January, with extremes recorded as low as -45° F.

Due to the rugged topography, deep canyons with steep sideslopes and broad plateaus, the area has a wide variety of climate over short distances. Precipitation usually increases with an increase in elevation.

Approximately half of the estimated average annual precipitation of 16 to 18 inches occurs during the growing season. This factor will be of considerable advantage in revegetating the study area. Average snowfall is over 80 inches per year, but it has only a moderate moisture content. The snowpack begins to develop in late October, and snowmelt normally begins in April and continues into early July.

The prevailing winds are from the southwest at 3 to 5 miles per hour (mi/h). About 10 percent of the time the winds blow out of the northeast. Winds of up to 100 mi/h have been recorded in the area; however, fair weather winds rarely exceed 25 mi/h.

The frost-free period averages 80 to 90 days. The growing season for hardy grasses (average consecutive days above 28° F) is between 100 and 120 days.

The climate should have little adverse affect on reestablishment of vegetative cover. The climatic conditions of a high percent of summer sunshine, adequate rainfall (especially frequent summer showers), and mild summer temperatures are conducive to the successful establishment and rapid growth of adapted plant species.

Physiography

The study site is located south of the Axial Basin in the southern part of the Wyoming Basin physiographic province of the Rocky Mountain Region. The Wyoming Basin covers approximately 40,000 square miles in northwestern Colorado and southern Wyoming. Steep mountain slopes border

the basin on the north and south. The Wyoming Basin is a plateau area underlain by widespread deposits of relatively soft sedimentary rocks and containing isolated mountain ridges.

The Collom Gulch study area is characterized by rolling hills, moderately sloping broad ridgetops, and steep canyons. Narrow V-shaped valleys are cut between the ridgetops which have valley walls of 40 to 100 percent grade. These V-shaped valleys are the result of stream cutting through the sandstone and shale beds and are roughly parallel to each other. Figure 3 shows the topography of the study area.

Geology

The dominant structural feature of the area is the great uplift or arch known as the Axial Basin anticline. The anticline is believed to be a southeastward extension of the larger Uinta Mountain uplift. The Axial Basin anticline is an asymmetrical fold with the dips on the south flank being much steeper than those on the north. The sandstones and shales which formed the crest of the anticline have been eroded away to expose the Cretaceous Mancos Shale (Km) in the center of the basin. Progressively younger rocks are exposed on the flanks of the fold and form a near-continuous escarpment which surrounds the basin. The axis of the anticline trends approximately N. 60° W. and extends from Little Juniper Mountain (T. 6 N., R. 94 W.) to Thornburgh Mountain (T. 3 N., R. 92 W.).

The south flank of the anticline forms the north flank of the Collom syncline. The axis of the syncline parallels that of the anticline and lies approximately 1 mile north of the study site. The syncline is also an asymmetrical fold with the beds on the north flank dipping more steeply than those on the south.

Exposed rocks in the general vicinity of the study site are sedimentary in origin and Cretaceous and Tertiary in age. Exposed sequences include thick accumulations of sandstone, siltstone, shale, and coal. A generalized stratigraphic section of these sedimentary rocks is shown in Figure 4 on page 12 (Plate 18, USGS Bulletin 1027).

The Upper Cretaceous Mancos Shale (Km) underlies the study site at depth and is exposed north of the site in Axial Basin. Literature describes the unit as being approximately 4,600 feet thick and consisting of grey marine shale and interbedded sandstone in the uppermost part of the formation. The sandstone units are silty, very fine to fine grained, and generally thin bedded.

The Iles Formation (Ki) conformably overlies the Mancos and is exposed along the escarpment surrounding the basin. The formation is not exposed at the study site. The Iles is approximately 1,500 feet thick and consists of interbedded sandstone, shale, and coal beds. Its uppermost member, the Trout Creek Sandstone, separates the Williams Fork and

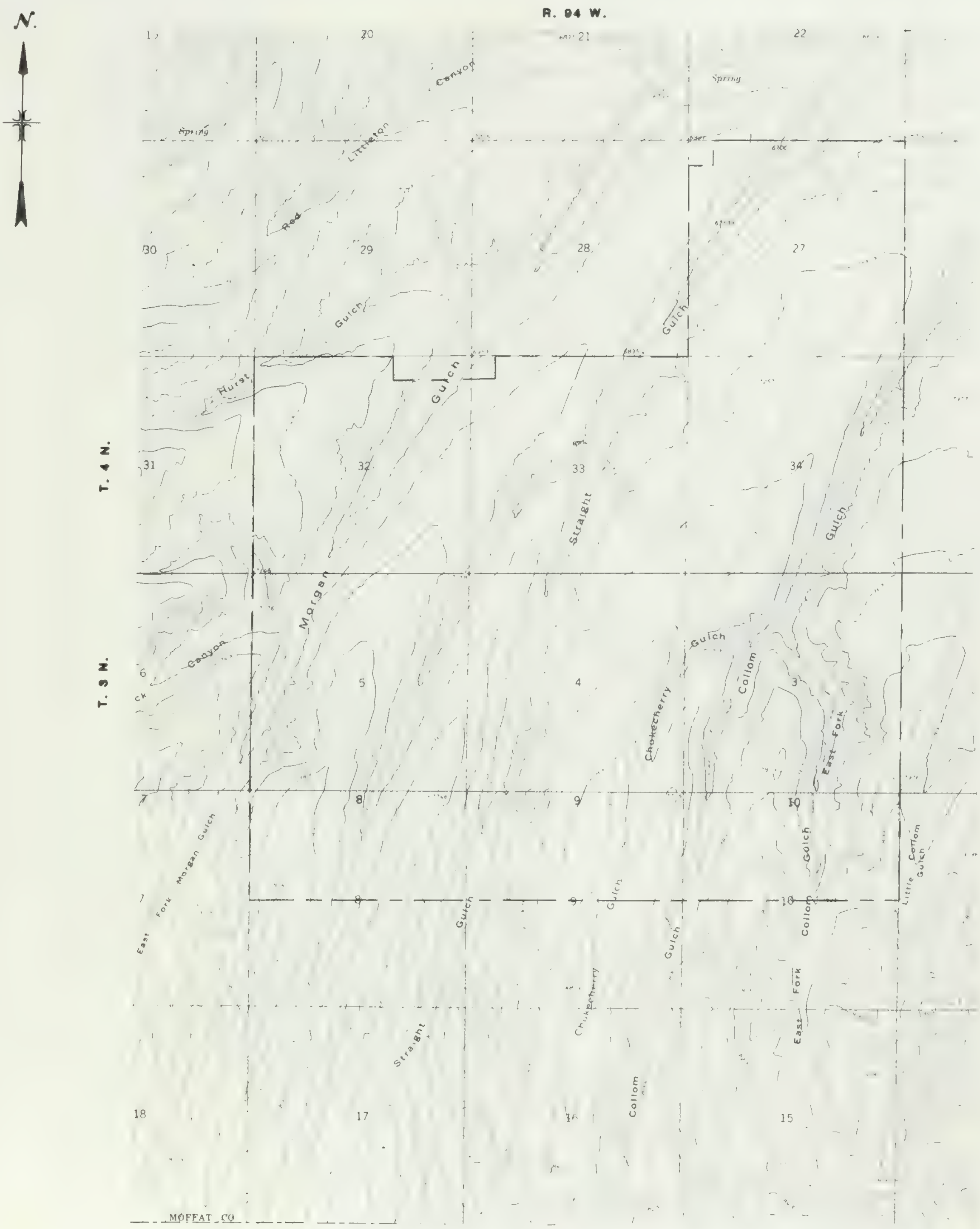


Figure 3

1000 0 1000 2000 3000

SCALE OF FEET

ALWAYS THINK SAFETY

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

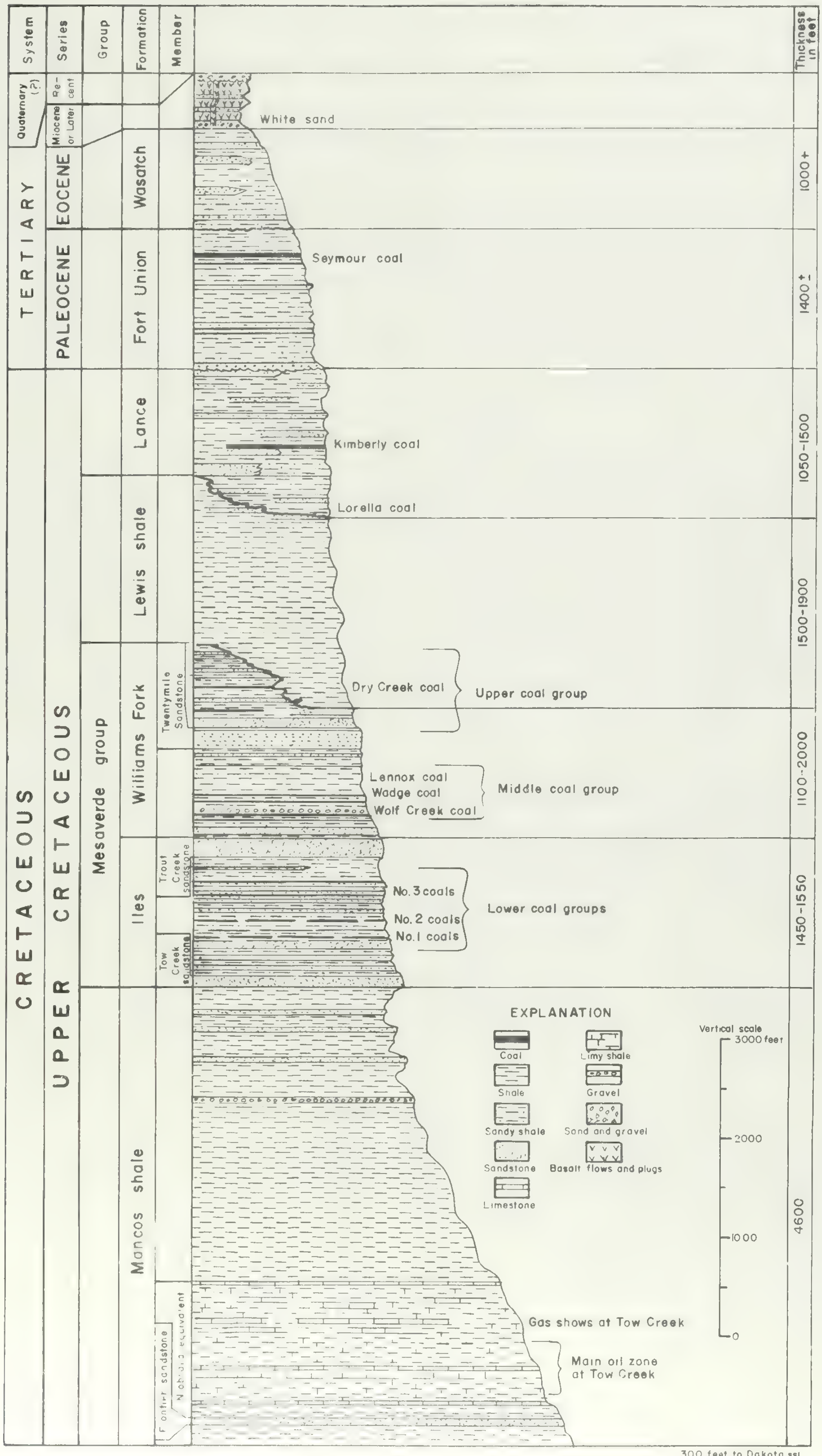
COLLOM GULCH SITE

TOPOGRAPHY & LOCATION MAP

DESIGNED ______ TECHNICAL APPROVAL ______
DRAWN ______ SUBMITTED ______
CHECKED ______ APPROVED ______

SALT LAKE CITY, UTAH SEPTEMBER 1983

Figure 4



GENERALIZED COLUMNAR SECTION OF EXPOSED ROCKS
IN PARTS OF ROUTT AND MOFFAT COUNTIES, COLORADO

Iles Formations and forms a prominent white ledge that can be traced for miles around the basin.

The Williams Fork Formation (Kw) is exposed over a broad region extending from the Danforth Hills, through the study site, and northward to the south rim of the Axial Basin. The formation is 1,100 to 2,000 feet thick and consists of interbedded sandstone, siltstone, shale, and coal beds. Two of the coal seams found in the middle portion of the unit, the Lennox and Wadge seams, are quite thick east of the study area and are of economic importance.

Geologic Investigations

Geologic investigations were conducted in the study area by the Bureau of Reclamation between June and October 1980. These investigations included geologic mapping and the drilling of five core holes. Geologic mapping on a scale of 1-inch equals 2,000 feet was completed on aerial photographs and transferred to 7½-minute quadrangle maps. The purpose of the drill holes was to obtain samples of overburden for complete soils analysis. Drilling was completed with a skid-mounted Sprague and Henwood Drill, and core was recovered using HQ wireline equipment (2½-inch-diameter sample). Water, obtained from local springs, was used as the drilling medium. Hole depths ranged from 206.6 feet (DH-4) to 326.9 feet (DH-2).

Clayey slopewash deposits cover much of the site to a depth of approximately 5 feet. Recovered core samples indicate that the site is underlain by interbedded, very fine- to medium-grained sandstone, carbonaceous siltstone and shale, and coal of the Cretaceous Williams Fork Formation. For detailed lithologic descriptions, refer to the geologic logs on pages 71 to 89. Outcrops of the Williams Fork occur primarily along canyon rims and are frequently baked and fused.

A more complete discussion of the geology of the study site, including geologic data and drill hole locations and logs, is presented in Appendix A.

Coal Resources

Coal was found in each of the five holes with thickness ranging from thin partings to an 11.5-foot-thick seam in DH-3. Average coal seam thickness encountered in drill holes DH-1 through DH-5 was 1.7 feet (10 seams), 1.5 feet (9 seams), 3.0 feet (11 seams), 2.2 feet (9 seams), and 4.4 feet (10 seams), respectively. Most of the seams were less than 3 feet thick. Only one other seam of significant thickness was found--a 10.7-foot-thick bed in DH-5. The Lennox and Wadge seams, found east of the study site, were not encountered during drilling but are believed to underlie the site at depth.

Coal samples from Reclamation's drilling program (5 drill holes) were delivered to the USGS in Denver for quality analysis. These data

are presented in Appendix B, Coal Analysis. No attempt was made to estimate the onsite coal resources for the study site.

Soils and Overburden

A detailed land classification survey was made of the area to determine the quality and location of suitable soil and overburden material that could be used as a plant growth media to cover the reshaped and contoured disturbed areas.

The land classification specifications used were similar to those developed for the Bureau of Reclamation's arable land classification used for irrigation development. The classification takes into consideration the following factors: texture, depth, salinity, sodicity, permeability, available water-holding capacity, erodibility, and topography. It considers how these factors act individually or in combination with each other in determining suitability as a source of stockpiled plant growth media.

The land was classified into four classes--three suitable classes (1, 2, and 3) and one unsuitable class (class 6). Class 1 lands are the best source of planting media. They are over 3 feet in depth, have no restrictions, and occupy 1 percent or 75 acres of the area. Class 2 lands have slight limitations and are less suitable, usually expressed by shallow depth, for plant growth media. They are usually shallower or have some other slight deficiency which makes them less suitable than class 1 lands. They make up 26 percent (1,427 acres) of the study site. Class 3 lands have more serious deficiencies such as shallow depths, steep topography, high salt content, or stoniness. They have limited suitability for planting media and occupy 850 acres or 16 percent of the area. Class 6 lands are unsuitable as a strippable, stockpiled plant growth media because of their physical and/or chemical properties. They occupy 57 percent of the Collom Gulch site.

There should be adequate soil as stockpiled plant growth media to top-dress the reshaped disturbed land areas to a sufficient depth to support revegetation of the site.

General Soil Characteristics

Collom Gulch soils are mostly residual in origin. Parent material consists primarily of eroded alternating beds of shale, sandstone, and mudstone of the Williams Fork and Iles members of the Mesaverde Formation. These soils are found mostly on the sloping ridgetops and sideslopes. The valley or canyon bottom soils are alluvial in origin and are derived from the same parent materials.

The soils found on the broad to narrow ridgetops that slope to the north and northeast, with gradients of from 3 to 15 percent, vary in depth and other soil characteristics, with position being an important

determining factor. Soils on the steep, west-facing slopes are shallow (6 to 12 inches in depth and dark in color) while the soils on the steep, east-facing slopes are shallow (less than 6 inches in depth), lighter in color, and stony to rocky. Vegetation is scant on east-facing slopes compared to that on west-facing slopes and ridgetops.

The soils of the valley or canyon bottoms are alluvial in origin, dark in color, stratified, and moderately deep. These soils are higher in organic matter but, like all soils of the area, are highly calcareous.

Surface textures for the ridgetop and sideslopes range from sandy loam to silty clay loam with most surface textures loam to clay loam. The alluvial soils are loam to clay loam on the surface.

Subsoil textures are predominantly clay loam and clay. The alluvial soils are stratified and may contain lenses of gravel. Small alluvial fans occur on side drainages and these soils are generally stony.

Land Suitability Survey

The purpose of the land suitability survey was to determine the area and relative quality of the strippable plant growth media in the study area.

The specifications shown in Table 2 on the following page were developed to characterize four land suitability classes. Classes 1, 2, and 3 are suitable for plant growth media and class 6 is unsuitable. Classes 1 to 3 roughly correspond to the Bureau of Reclamation's arable land classification for irrigation development. Some of the factors used to develop the suitability classification include the following physical characteristics: depth, texture, permeability, development, slope, erodibility, and surface rock or bedrock. The chemical characteristics studied included salinity, sodicity, organic matter content, and toxic elements.

Description of land suitability classes

Class 1

Class 1 lands are the best source of strippable planting media. They are of the highest quality, have greater depth, and are the easiest to strip and stockpile. If not strip mined, these areas could be a borrow area for plant media.

Class 2

Class 2 lands are less suitable due to some slight limitation. The limitation may be one of the following factors: shallow depth, high salt content, lower water-holding capacity, restricted or excessive permeability, or moderate erosion susceptibility. They may also be downgraded because they are more expensive and difficult to strip and stockpile.

Table 2
Land classification specifications[1]
Suitability of surface materials for revegetation of surface-mined areas

	Land class 1	Land class 2	Land class 3
Soils[2]			
Texture	Loam to light clay	Silty loam to clay	Fine sand; loamy sand to clay
Available water-holding capacity	>1.75"/foot of depth	>1.0"/foot of depth	>0.75"/foot of depth
Permeability	Adequate to provide a well drained and aerated root zone; and an infiltration rate adequate to prevent serious erosion	Slightly excessive for medium textures and slightly restrictive for fine texture soils	Excessive or restrictive to the extent that special consideration should be given to depth of replacement media on slopes of reshaped spoil banks
Salinity	<4 millimhos	<8 millimhos	<12 millimhos
Sodicity	<10 ESP[3]	<10 ESP[3]	<15 ESP[3]
Erodibility	Subject to slight erosion	Susceptible to moderate erosion	Susceptible to severe erosion but can be controlled with proper management practices
Depth	36 inches plus of usable and strippable material	18 inches plus of usable and strippable material	8 inches plus of usable and strippable material[4]
Topography[5]			
Slope	<20 percent	<20 percent	<35 percent
Surface rocks	<5 percent	5 percent	5 to 10 percent
Surface rock and bedrock croppings	Will not affect stripping, placing, or quantity of suitable material	Will not affect stripping, placing, or quantity of suitable material	Numerous enough to reduce quantity of suitable material appreciably and make stripping expensive
Weatherability[6]	Will breakdown readily upon exposure to the weather	May require short period to breakdown upon exposure	May require extended period to breakdown into optimum particle-size distribution but can be used in less desirable state in reasonable time period
Drainage[7]			
Class 6[8]			

1/ Specifications are based on rainfed conditions or a minimum of irrigation for starting plantings and maintenance through dry periods.

2/ Pertains to undisturbed soil and to minimum depth (1.0 foot) of soil redistributed over unconsolidated cast overburden.

3/ Exchangeable sodium percentage.

4/ Six inches is considered as the minimum strippable depth.

5/ Topographic factors considered are related primarily to stripping operations. Surface rock is a soil deficiency not a topography deficiency in this study.

6/ Weatherability is applicable only to bedrock or unconsolidated material.

7/ Because of land alterations by surface mining, present drainage conditions, excepting the permeability of the material, are not a factor in the classification.

8/ All areas not meeting the minimum requirements for classes 1, 2, or 3. These lands are unsuited as a source of material (topsoil) for revegetation.

Class 3

Class 3 lands have one or more deficiencies which more severely restrict their suitability as plant growth media. They are usually shallow, steep, and may be difficult to strip and stockpile. They may have high salt content, low water-holding capacity, restricted or excessive drainage, or moderate to severe erosion hazard.

Class 6

Class 6 lands are unsuitable for plant growth media. They are usually steep and shallow. They may have other physical or chemical characteristics which make them unsuitable.

Procedures

The suitability of the soils of the Collom Gulch site was determined by using the above specifications. The soils' physical and chemical characteristics, topography, and drainage were examined in sufficient detail to determine its class and extent. The field delineations were confirmed by the laboratory data on field samples taken from the typical profiles, deep auger holes, and other representative sites. The land classes or mapping units were delineated in the field on base maps having a scale of 1 to 4,800. The mapping legend is shown in Figure 5.

The soils investigations were made with a 3.25-inch hand auger and a truck-mounted, 18-inch power auger (Texoma) with a depth capacity of 25 feet.

There were 21 power auger holes dug with the Texoma auger and 86 hand auger borings made. Three typical profile pits were dug using the Texoma auger. Data on soil horizons, color, texture structure, and consistency were recorded, and soil samples for each horizon were collected for laboratory analysis.

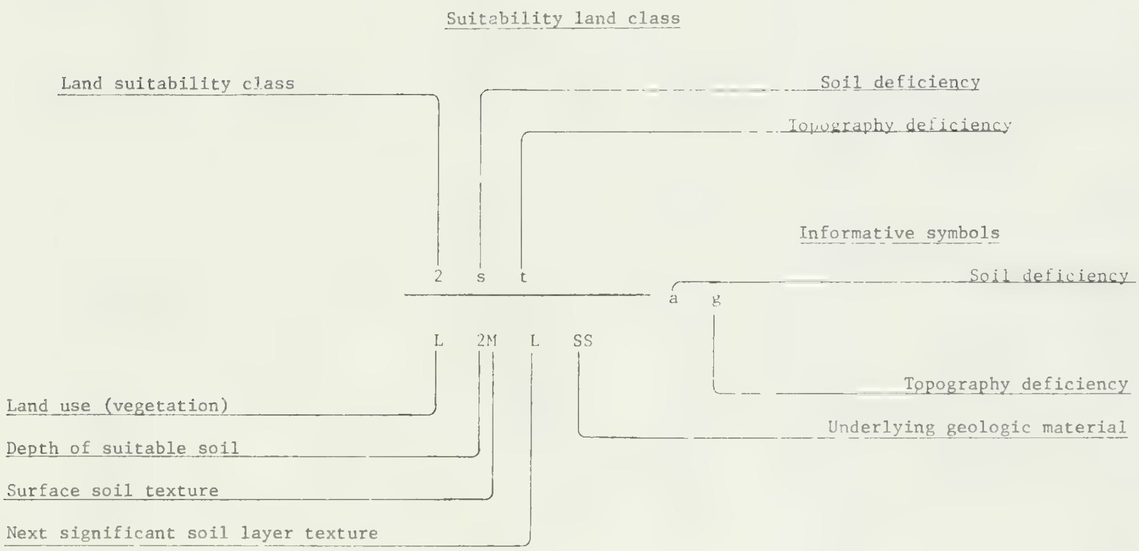
Laboratory procedures and methods used in the screening tests were from the Bureau of Reclamation's Instructions, Series 510, Part 117, "Laboratory Procedures." The Department of Agriculture's Handbook 60, "Diagnosis and Improvement of Saline and Alkali Soils," and Part 2 of Agronomy 9, "Methods of Soil Analysis," were also used.

A complete soil analysis was run on 79 samples from the 3 typical profiles, 5 drill holes, and 11 auger holes. Screening tests were run on 31 samples from 14 hand auger borings, 88 samples on 18 Texoma borings, and 224 samples from the 5 drill holes.

The results of these analyses and a description of the three typical profiles are presented in Appendix C of this report.

FIGURE 5

MAPPING SYMBOL



Land suitability class
- 1 Good
- 2 Fair
- 3 Poor
- 6 Unsuitable

Subclass deficiency
- s Soil
- t Topography

Underlying geologic material
- SS Sandstone
- Sh Shale
- MS Mudstone

Texture
- L Loamy sand, sandy loam, loam
- M Silty loam, clay loam, silty clay loam
- H Sandy clay, silty clay, clay

Informative symbols

Salinity		
a	Class 2	< 8 millimhos
	Class 3	<12 millimhos
Sodicity		
s	Class 2	<10 ESP
	Class 3	<15 ESP
Topography		
g		10 to 20 percent slope
j		Moderately rolling
Soil		
h		Fine texture
k		Shallow depth to gravel/cobble
r		Surface rock
v		Coarse texture

Summary of land classification

A total of 5,414 acres was mapped at the Collom Gulch study area. Seventy-five acres of class 1 land were mapped primarily in secs. 5 and 32 on the bottom lands of Morgan Gulch.

Class 2 lands made up 26 percent of the study area or 1,427 acres. They are scattered throughout the area with most of the class 2 lands in secs. 4, 27, and 34.

Class 3 lands represent 16 percent of the area or 850 acres. They are scattered throughout the area and represent most of the suitable lands in the study site.

Fifty-seven percent, or 3,062 acres of the area, were classified as unsuitable or class 6 lands. Table 3 shows the tabulation of the four land classes by section.

Table 3
Summary of classified area
(Unit--acres)

Township, range, and section	Suitability class: Class 1	Class 2	Class 3	Total of classes 1 through 3	Class 6	Total classified
T. 3 N., R. 93 W.						
sec. 3		119.5	22.7	142.2	505.0	647.2
sec. 4		203.4	60.7	264.1	380.7	644.8
sec. 5	36.4	130.0	100.4	266.8	376.1	642.9
sec. 8		14.7	96.8	111.5	208.5	320.0
sec. 9		37.6	69.3	106.9	213.1	320.0
sec. 10		7.9	39.9	47.8	272.2	320.0
Subtotal	36.4	513.1	389.8	939.3	1,955.6	2,894.9
T. 4 N., R. 93 W.						
sec. 27	6.5	304.2	52.6	363.3	267.6	630.9
sec. 32	32.1	196.2	172.9	401.2	215.2	616.4
sec. 33		143.5	167.5	311.0	320.3	631.3
sec. 34		270.4	66.8	337.2	302.8	640.0
Subtotal	38.6	914.3	459.8	1,412.7	1,105.9	2,518.6
Total	75.0	1,427.4	849.6	2,352.0	3,061.5	5,413.5
Total rounded	75	1,427	850	2,352	3,062	5,414
Percent of area	1	26	16	43	57	100

Overburden

The overburden of the Collom Gulch site is composed of the Iles and the Williams Fork geological formations. The Iles Formation is approximately 1,500 feet thick and is composed of interbedded sandstone, shale, and coal beds. The Williams Fork Formation is 1,100 to 2,000 feet thick and consists of interbedded sandstone, siltstone, shale, and coal beds. Most of the strippable coal is found in the Williams Fork Formation.

Five deep core holes were drilled in the study site to obtain information on the geology and samples for analysis of the overburden. The drill logs are presented in Appendix A, Geologic Data, at the end of this report. The drill log for DH-3 is presented as Figure 6 on pages 20 to 22. It is typical of the information found in the other four drill holes.

7-1337 (6-74)
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GEOLOGIC LOG OF DRILL HOLE

FIGURE 6 SHEET 1 OF 3

FEATURE Collom Gulch Study Site PROJECT Emria STATE Colorado

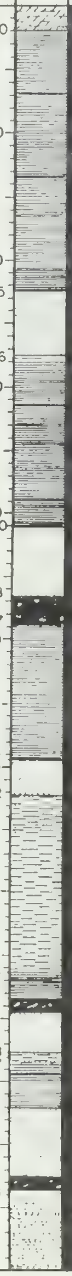
HOLE NO. DH-3 LOCATION NW¼ NE¼, SEC 34, T4N, R.94W. GROUND ELEV. 7290± 1/ DIP (ANGLE FROM HORIZ.) 90.0 degrees Down

COORDS. N. ... E. ...

BEGUN 09-23-80 FINISHED 09-27-80 DEPTH OF OVERBURDEN 2.0' TOTAL DEPTH 306.6' BEARING ...

DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED Not Measured LOGGED BY D. Grundvig LOG REVIEWED BY F. Thompson

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS	TYPE AND SIZE OF HOLE	CORE RECOVERY (%)	SUITABILITY OF OVERBURDEN	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	SAMPLES FOR TESTING	CLASSIFICATION AND PHYSICAL CONDITION



NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS

NOTE: 1/ All measurements are from the ground surface. Hole was not surveyed, deviation (if any) from vertical is unknown.

PURPOSE OF HOLE: To obtain samples for determination of overburden properties.

DRILLING EQUIPMENT: Skid-mounted Sprague and Henwood

DRILLING FLUID: Water, recirculated

DRILLING FLUID LOSSES: Drillers reported no water return from 0.0' to 36.5', no losses from 36.5' to 76.6', 80% loss from 76.6' to 156.6', no losses from 156.6' to 206.6, and 25 to 50% losses for the remainder of the hole.

CASING RECORD:

Cs Size (in.)	Depth of Cs (feet)	Hole Depth (feet)
-	-	20.0
4	19.0	20.0-306.6

HOLE COMPLETION: Geophysical logs were run in hole by U.S.G.S. Well points were installed with tips at 239.2' and 292.7' (10' influence zones) for ground water studies. No unusual drilling conditions, other than loss of water, were reported by drillers.

TYPE AND SIZE OF HOLE / CORE RECOVERY (%)

Depth (feet)	Type and size of hole	Core recovery (%)
0-20	RB	0
20-30	HQ Wire-line ($3\frac{1}{2}$")	100
30-40		100
40-50		96
50-60		85
60-70		100
70-80		100
80-90		100
90-100	HQ Wire-line ($3\frac{1}{2}$")	100
		or

SUITABILITY OF OVERBURDEN

Interval (feet)	Suitable	Limited Suitability	Unsuitable
0.0-2.0	+		
2.0-46.8		+	
46.8-48.7			COAL
48.7-78.6		+	
78.6-79.4			COAL
79.4-92.5		+	
92.5-93.8			COAL
93.8-100.0			+

ELEVATION (FEET) / DEPTH (FEET)

Elevation (feet)	Depth (feet)
7290.0	0.0
7288.0	2.0
7267.5	22.5
7262.4	27.6
7249.0	41.0
7243.2	46.8
7241.3	48.7
7230.5	59.5
7227.8	62.2
7213.6	76.4
7211.4	78.6
7210.6	79.4
7207.2	82.8
7206.3	83.7
7203.0	87.0
7197.5	92.5
7196.2	93.8
7190.0	100.0

CLASSIFICATION AND PHYSICAL CONDITION

Driller: J. Dunn & K. Rasmussen, B.O.R.

0.0 - 2.0: Lean Clay: Approximately 70% fines with medium plasticity, 30% fine sand, slight to moderate reaction with HCL, dark to light brown, dry. (CL)

2.0 - 306.6: Cretaceous Williams Fork Formation (Kw)
Interbedded sandstone, siltstone, shale, and coal. Individual units are described below.

Sandstone: principally quartzose but may be argillaceous and calcareous in part, very fine to medium, subangular to subrounded grains, fresh to moderately weathered, weakly to well cemented, bedding indistinct, lightly jointed, black carbonaceous swirls and laminations in part, occasional slickensides, slight to moderate porosity, light gray to yellow brown, strong to no reaction with HCL. Core recovered in fragments and lengths to 3.0' (most are less than 1.5'). Most contacts are gradational.

Siltstone: carbonaceous and sandy in part, frequent shale partings, fresh to moderately weathered, moderately hard, moderately well cemented, indistinct bedding, lightly jointed, occasional near-vertical fractures and slickensides, light to dark gray, frequent leaf imprints, slight to strong reaction with HCL. Core recovered in 0.1' to 0.7' lengths. Most breaks are inclined approximately 8-10 degrees to the horizontal with rough, irregular surface. Most contacts are gradational.

Shale: carbonaceous and sandy in part, fresh to moderately weathered, slight to moderate air slaking, fissility poorly to moderately developed. Occasional slickensides, gray to black, slight to no reaction with HCL. Core recovered in fragments to 0.4' lengths. Most contacts are gradational.

EXPLANATION

CORE LOSS
CORE RECOVERY

RB = rock bit
Fe = oxides of iron, i.e, limonite, hematite
HCL = hydrochloric acid (10% solution)

Type of hole ... D = Diamond, H = Haystellite, S = Shot, C = Churn
Hole sealed ... P = Packer, Cm = Cemented, Cs = Bottom of casing
Approx. size of hole (X-series). Ex = 1-1/2", Ax = 1-7/8", Bx = 2-3/8", Nx = 3"
Approx. size of core (X-series). Ex = 7/8", Ax = 1-1/8", Bx = 1-5/8", Nx = 2-1/8"
Outside dia. of casing (X-series). Ex = 1-13/16", Ax = 2-1/4", Bx = 2-7/8", Nx = 3-1/2"
Inside dia. of casing (X-series). Ex = 1-1/2", Ax = 1-29/32", Bx = 2-3/8", Nx = 3"

FEATURE Collom Gulch Study Site PROJECT Emria STATE Colorado SHEET 1 OF 3 HOLE NO DH-3

☆GPO 679-482

7-1337 (8-74)
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GEOLOGIC LOG OF DRILL HOLE

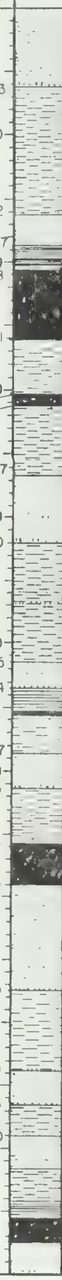
FIGURE 6 SHEET 2 OF 3

FEATURE: Collom Gulch Study Site	PROJECT: Emria		STATE: Colorado
HOLE NO. DH-3	LOCATION: NW¼ NE¼, SEC 34, T4N, R. 94W.	GROUND ELEV. 7290±	DIP (ANGLE FROM HORIZ.) 90.0 degrees Down
	COORDS. N. ... E. ...		
BEGUN 09-23-80	FINISHED 09-27-80	DEPTH OF OVERBURDEN 2.0'	TOTAL DEPTH 306.6' BEARING
DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED: Not Measured	LOGGED BY: D. Grundvig		LOG REVIEWED BY: F. Thompson

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS | TYPE AND SIZE OF HOLE | CORE RECOVERY (%) | SUITABILITY OF OVERBURDEN (SUITABLE / LIMITED SUITABILITY / UNSUITABLE) | ELEVATION (FEET) | DEPTH (FEET) | GRAPHIC LOG | SAMPLES FOR TESTING

Depth (feet)	Elevation (feet)	Core recovery (%)	Suitability of overburden
100.0 – 106.3	7190.0 – 7183.7	100	Unsuitable
106.3 – 120.8	7183.7 – 7169.2	100	Limited suitability
120.8 – 126.1	7169.2 – 7163.9	100	Unsuitable (COAL)
126.1 – 130.4	7163.9 – 7159.6	100	Limited suitability
130.4 – 131.3	7159.6 – 7158.7	100	Unsuitable (COAL)
131.3 – 151.5	7158.7 – 7138.5	100	Unsuitable
151.5 – 153.4	7138.5 – 7136.6	100	Limited suitability
155.8 – 158.7	7134.2 – 7131.3	100	Unsuitable
158.7 – 161.3	7131.3 – 7128.7	100	Limited suitability
161.3 – 165.8	7128.7 – 7124.2	100	Unsuitable
165.8 – 169.0	7124.2 – 7121.0	100	Unsuitable (COAL)
169.0 – 195.6	7121.0 – 7094.4	100	Unsuitable
195.6 – 197.4	7094.4 – 7092.6	100	Unsuitable (COAL)
197.4 – 200.0	7092.6 – 7090.0	100	Unsuitable

Elevation / depth marks: 7190.0 / 100.0; 7183.7 / 106.3; 7173.8 / 116.2; 7171.3 / 118.7; 7169.2 / 120.8; 7163.9 / 126.1; 7159.6 / 130.4; 7158.7 / 131.3; 7153.3 / 136.7; 7148.0 / 142.0; 7138.5 / 151.5; 7136.6 / 153.4; 7134.2 / 155.8; 7131.3 / 158.7; 7128.7 / 161.3; 7124.2 / 165.8; 7121.0 / 169.0; 7112.5 / 177.5; 7106.1 / 183.9; 7103.5 / 186.5; 7101.0 / 189.0; 7098.3 / 191.7; 7095.9 / 194.1; 7094.4 / 195.6; 7092.6 / 197.4; 7090.0 / 200.0



Driller: J. Dunn & K. Rasmussen
B.O.R.

CLASSIFICATION AND PHYSICAL CONDITION

Coal: dull to shiny black core recovered in fragments and lengths to 0.7'. Occasional shale parting.
2.0 - 22.5: Shale, intensely weathered, soft and crumbly.
22.5 - 27.6: Sandstone, Fe stained throughout.
27.6 - 41.0: Shale, occasional slickensides (70-85 degrees to the horizontal).
41.0 - 46.8: Sandstone
46.8 - 48.7: Coal
48.7 - 59.5: Shale
59.5 - 62.2: Sandstone, gray to white.
62.6 - 76.4: Siltstone, some coal streaks.
76.4 - 78.6: Shale
78.6 - 79.4: Coal
79.4 - 82.8: Sandstone
82.8 - 83.7: Siltstone
83.7 - 87.0: Shale, black.
87.0 - 92.5: Sandstone
92.5 - 93.8: Coal
93.8 - 106.3: Sandstone
106.3 - 116.2: Siltstone, carbonaceous in lower part.
116.2 - 118.7: Sandstone
118.7 - 120.8: Shale
120,8 - 126.1: Coal
126.1 - 130.4: Siltstone, shale parting at contact with coal.
130,4 - 131,3: Coal
131,3 - 136,7: Siltstone
136,7 - 142.0: Sandstone
142,0 - 151.5: Siltstone, with shale and sandstone lenses.
151.5 - 153.4: Sandstone
153.4 - 155.8: Shale, black.
155.8 - 158.7: Siltstone
158.7 - 161.3: Sandstone, salt and pepper appearance.
161.3 - 165.8: Siltstone
165.8 - 169.0: Coal
169,0 - 177,5: Sandstone
177,5 - 183.9: Siltstone, with shale lenses, dark gray to black.
183.9 - 186.5: Sandstone
186.5 - 189.0: Siltstone, with frequent shale partings.
189.0 - 191.7: Sandstone
191.7 - 194,1; Siltstone, several slickensides.
194.1 - 195.6: Shale
195,6 - 197,4: Coal
197.4 - 200.6: Sandstone
200,6 - 210.8: Siltstone, some black shale and coal streaks near bottom of interval.
210.8 - 231.4: Sandstone, slight Fe staining in part.

EXPLANATION

CORE LOSS
CORE RECOVERY

Type of hole . . . D = Diamond, H = Haystellite, S = Shot, C = Churn
Hole sealed . . . P = Packer, Cm = Cemented, Cs = Bottom of casing
Approx. size of hole (X-series) . . Ex = 1-1/2", Ax = 1-7/8", Bx = 2-3/8", Nx = 3"
Approx. size of core (X-series) . . Ex = 7/8", Ax = 1-1/8", Bx = 1-5/8", Nx = 2-1/8"
Outside dia. of casing (X-series) . Ex = 1-13/16", Ax = 2-1/4", Bx = 2-7/8", Nx = 3-1/2"
Inside dia. of casing (X-series) . Ex = 1-1/2", Ax = 1-29/32", Bx = 2-3/8", Nx = 3"

FEATURE Collom Gulch Study Site PROJECT Emria STATE Colorado SHEET 2 OF 3 HOLE NO. DH-3

☆ GPO 679 487

7-1337 (8-74)
Bureau of Reclamation

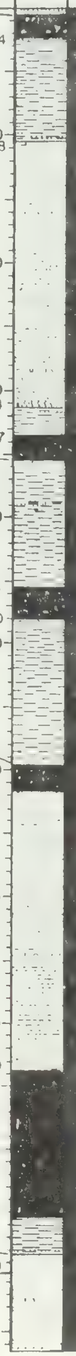
GEOLOGIC LOG OF DRILL HOLE

FIGURE 6 SHEET 3 OF 3

FEATURE Collom Gulch Study Site PROJECT Emria STATE Colorado
HOLE NO. DH-3 LOCATION NW¼ NE¼, SEC 34, T4N, R. 94W. GROUND ELEV. 7290± DIP (ANGLE FROM HORIZ.) 90.0 degrees Down
COORDS. N. E.
BEGUN 09-23-80 FINISHED 09-27-80 DEPTH OF OVERBURDEN 2.0' TOTAL DEPTH 306.6' BEARING
DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED Not Measured LOGGED BY D. Grundvig LOG REVIEWED BY F. Thompson

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS	TYPE AND SIZE OF HOLE	CORE RECOVERY (%)	SUITABILITY OF OVERBURDEN: SUITABLE	LIMITED SUITABILITY	UNSUITABLE	ELEVATION (FEET)	DEPTH (FEET)
						7090.0	200.0
		100			+++	7089.4	200.6
					COAL	7087.6	202.4
		100			+++	7079.2	210.8
		100		+++			
		100		+++			
		100		+++		7058.6	231.4
					+++	7056.3	233.7
					COAL	7054.4	235.6
		100			+++	7044.5	245.5
					COAL	7042.0	248.0
		100			+++	7030.3	259.7
		100			COAL	7028.1	261.9
		100		+++			
		100		+++		7006.1	283.9
		100			COAL	6994.6	295.4
		100		+++		6991.7	298.3
						6990.0	300.0
	HQ Wire-line					6983.4	306.6

GRAPHIC LOG



CLASSIFICATION AND PHYSICAL CONDITION

231.4 - 233.7: Siltstone, carbonaceous
233.7 - 235.6: Coal
235.6 - 245.5: Siltstone, black and carbonaceous in part.
245.5 - 248.0: Coal
248.0 - 259.7: Siltstone, with frequent shale lenses, light air slaking.
259.7 - 261.9: Coal
261.9 - 283.9: Sandstone, with frequent siltstone lenses to 0.3' thick.
283.9 - 295.4: Coal
295.4 - 298.3: Siltstone
298.3 - 306.6: Sandstone, laminated in upper part only.

TOTAL DEPTH 306.6'

CORE LOSS
CORE RECOVERY

Type of hole . . . D = Diamond, H = Haystellite, S = Shot, C = Churn
Hole sealed . . . P = Packer, Cm = Cemented, Cs = Bottom of casing
Approx. size of hole (X-series) . . Ex = 1-1/2", Ax = 1-7/8", Bx = 2-3/8", Nx = 3"
Approx. size of core (X-series) . . Ex = 7/8", Ax = 1-1/8", Bx = 1-5/8", Nx = 2-1/8"
Outside dia. of casing (X-series) . Ex = 1-13/16", Ax = 2-1/4", Bx = 2-7/8", Nx = 3-1/2"
Inside dia. of casing (X-series) . . Ex = 1-1/2", Ax = 1-29/32", Bx = 2-3/8", Nx = 3"

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Samples from the five drill holes were used for chemical analysis, weathering tests, and greenhouse studies. The weathering tests were conducted on five sandstone, four shale, and five siltstone core samples. The accelerated laboratory weathering test consisted of 20 cycles of a wetting/thawing, drying, wetting, freezing cycle, and a 1-year natural weathering test.

The results of the weathering tests indicate that the sandstone samples were resistant to breaking down, while over half of the shale and siltstone samples weathered sufficiently to attain the texture necessary for use as plant growth media. The samples chosen for the weathering tests did not include those already breaking down but were of the more strongly cemented overburden material; therefore, a higher percentage of the overburden material would weather rapidly enough to be used as planting media. Most of the overburden material was rated as having limited suitability on its physical characteristics.

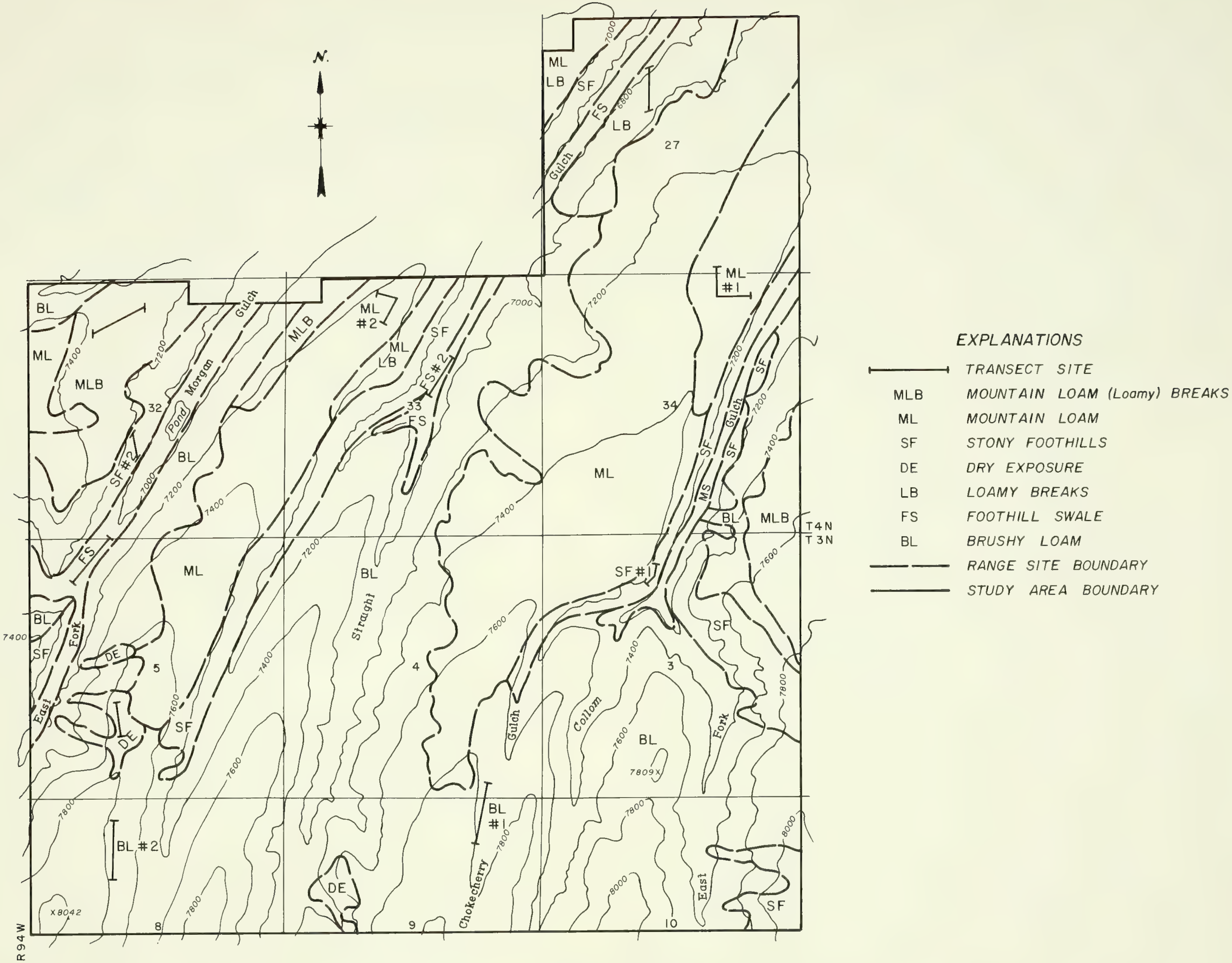
Chemical analysis was run on 225 samples of overburden. The pH ranged from 6.3 to 9.4, sodium adsorption ratio (SAR) ranged from 0.4 to 54.2, and electrical conductivity (EC X 10^3 at 25° C) varied from 0.06 to 6.09. Most of the overburden is suitable from a chemical standpoint except most of the overburden in drill hole 3 was unsuitable below 130 feet due to high sodium content. Results of the overburden suitability analysis are presented in Appendix C, Soils and Overburden; Appendix D, Greenhouse Studies; and Appendix E, Weathering Tests.

Vegetation

Introduction

The vegetation on the Collom Gulch study area was mapped into range sites (SCS), Figure 7. The range sites were mapped out according to variations of environmental factors and vegetation. Differences in environmental factors predominantly in climate, soil, and topography, result in differences in vegetation (kind, proportion, and production of plants). Areas of relative homogeneity within each range site were transected for vegetative cover, and species production was measured by weight. Vegetation cover was determined by utilizing a 10-point frame sampler (300 points per transect), and species production was determined by clipping 10 circular plots 9.68 square feet in area. Air-dry weight measurements for individual species were tabulated and utilized to generate species composition. The above data, and data contained in Appendix F, were evaluated with SCS range site descriptions of potential plant communities to generate the ecological seral stage represented by the transect information. The author recognizes that the range site descriptions are general in nature; therefore, references to ecological seral ratings should be interpreted with caution.

Table 1, Appendix F, titled, "Percent Cover by Component as Transected Within Each Range Site," interprets the transect data within each range site and separates the percent cover determinations into basic vegetation components, mulch, rock, and bare ground.



RANGE SITES

FIGURE 7

Table 2, Appendix F, titled, "Yield and Percent Cover by Component as Transected and Percent Composition as Transected Within Each Range Site," provides the following information as interpreted from the transect sheets.

1. Yield or production by vegetation component as transected within each range site.

2. Cover percentage by vegetation component as represented by the individual transect within the range sites.

3. Potential yield (production) as taken from the SCS range site descriptions.

4. Percent composition of the vegetation components (determined by weight yield) as represented by the individual transects within each range site.

5. Ecological seral-stage ratings for each transect within the range site. These ecological seral-stage ratings were derived from comparing the present vegetation production by species weight with the potential plant community species by weight.

Tables 3 through 5, Appendix F, list individual plant species and their yield (production by weight) as they occur by transect within each range site. Appendix F also serves as a good plant list for the study area.

A list of plants is included with each range site description (highest potential, plant community) and provides the allowed composition percentage (expressed by weight). Additional plants not listed in the range site description but encountered along the transect are shown in these lists as invaders and increasers with their corresponding percent composition (by weight).

There were six range sites identified and mapped within the study area, as described on this and the following pages.

The aerial photographs and field transect data sheets utilized for the vegetation inventory are located at the Little Snake resources area office, Craig District, Colo.

Range sites

Brushy Loam

The Brushy Loam range site occurs within the study area on gently rolling to steep upland slopes generally facing north and west between the 7,000- to 8,000-foot elevation. This range site within the study

area is often situated adjacent to Mountain Loam, Stony Foothills, and the Mountain Loam-Loamy Breaks Complex range sites. The photographs on the following page illustrate a Brushy Loam range site with a northwest exposure and a Mountain Loam-Loamy Break Complex.

Soils in this site are deep to moderately deep and are well drained. Surface layers are very dark brown loams, with some light clay loams. These soils can be slightly acid to mildly alkaline. Subsoils have moderate to strongly blocky or subangular blocky structures and are 10 to 30 inches (25 to 75 cm) thick. Surface layers have moderate to high intake rates. Subsoils have moderate to slow permeability. These soils are subject to slippage and slumping on steep slopes.

This range site comprises 2,932 acres (54 percent) within the study area. Two transects were completed. One was located on the west slope of Chokecherry Gulch in the NE¼ of sec. 9, and the second was located on the east portion of the ridge between East Fork of Morgan Gulch and an unnamed intermittent stream fork west of Straight Gulch. The approximate location of the second transect was the NW¼ sec. 8.

Characteristic plant community.--The vegetation aspect of this site is a shrub-dominated community; however, grasses with elk sedge make up 50 to 60 percent, while forbs contribute 15 to 20 percent, and shrubs 30 to 40 percent air-dry weight.

Gambel oak is the major shrub species, although some areas are dominated by Saskatoon serviceberry. Snowberry, common chokecherry, and rose are the principal shrub species. In certain localized places, mountain mahogany and fenollerbrush are common. Many grasses occur on this site, with slender wheatgrass, mountain brome, nodding bromegrass, lettermann's and Columbia needlegrass, and Kentucky bluegrass considered as the major species. Elk sedge, generally, is the most frequently occurring plant. Thurber fescue is important at higher elevations. Important forbs are aspen, peavine, fleabane, yarrow, American vetch, and lupine. This site is generally treeless, except for possibly a few scattered aspen, Douglas fir, or ponderosa pine. Production yields for this site vary from 1,500 pounds to 3,000 pounds, depending on the growth year (climate factors).

Survey information.--Two transects were taken within this range site, and subsequent evaluation of the data provided indicate the area is in a high fair seral stage with ratings of 49.5 percent and 43.9 percent, respectively. The measured production for the two transects was 992 pounds per acre and 1,013 pounds per acre, respectively. No explanation is available which would account for the low yields of these two sites; however, this concern should be addressed if this area is given further consideration for coal development and subsequent reclamation.

The species composition by weight for transect No. 1 indicates that the grass component was 6 percent; the forb component, 20 percent; and shrub component, 74 percent. Slender wheatgrass contributed 3.1 percent; elk sedge, 1.5 percent; and mountain brome, 1.1 percent toward the

Brushy Loam range site, northwest exposure.

Mountain Loam-Loamy Breaks looking southeast.

composition on the grass component. Western yarrow, silvery lupine, and aspen peavine contributed 1.8 percent, 1.3 percent, and 1.4 percent, representing the forb component of the species composition. Mountain snowberry, Saskatoon serviceberry, and Gambel oak dominate the shrub component and contribute 25.5 percent, 20.6 percent, and 23.8 percent of the species composition. Transect No. 2 for this range site differed from transect No. 1 primarily in that the grass and forb components far exceeded the yield of transect No. 1 with a composition of 25 and 36 percent, respectively. As expected, the shrub component composition was less than transect No. 1, comprising only 39 percent of the composition. The species diversity generally remained the same for both transects with the exception of the occurrence of Kentucky bluegrass on transect No. 2.

Plant species most likely to invade this site are tall rabbitbrush, knotweed thistle, dandelion, tar weed, mullein, annual grasses, and forbs.

Plant retrogression with heavy grazing will decrease slender wheatgrass, mountain brome, nodding bromegrass, Idaho and/or Arizona fescue and muttongrass/Columbia and lettermann's needlegrass, elk sedge, western wheatgrass, and Kentucky bluegrass; and several forbs will increase. As the plant community continues to degenerate, Gambel oak, Saskatoon serviceberry, snowberry, common chokecherry, and mountain big sagebrush will dominate, along with less palatable forest grasses. Tables 4 and 5 on the following two pages list the plants described for the Brushy Loam range site.

Dry Exposure

The Dry Exposure site is typically an exposed area on steep slopes, ridges, hilltops, or other harsh, treeless landscapes within more extensive range sites. Exposure to climatic elements plays a large role in determining where this range site occurs. Slopes can be gentle to steep on any aspect.

The soils are gravelly sandy loams to gravelly loams, light colored, with a thin topsoil and subsoil with moderate to rapid permeability. Low fertility and droughty desert pavement of fine to medium gravel to cobble are on the surface. There are 90.4 acres identified as Dry Exposure within the study area, comprising 1.67 percent of the landscape. Dry Exposures occurred between 7,400 feet to 8,120 feet in elevation on ridgetops and western exposures within the Brushy Loam range site.

As shown in the first photograph on page 31, one transect was taken on a Dry Exposure east of Morgan Gulch (sec. 5, SW¼NE¼) at 7,600 to 7,700 feet on a west to northwest aspect. This survey indicates the production to be approximately 791.0 pounds/acre with a vegetation cover of 21.7 percent.

Characteristic plant community.--The Dry Exposures are described as having a scoured appearance and lacking large shrubs. Grasses could

Table 4
Determination of ecological seral-stage rating
Brushy Loam range site

Potential plant community	Percent	Transect No. 1 Allowed	Transect No. 1 Exceeded	Transect No. 2 Allowed	Transect No. 2 Exceeded
Grasses					
Arizona fescue	0 to 5				
Basin wildrye	0 to 2				
Big bluegrass	0 to 5				
Bottlebrush squirreltail	0 to 2			0.3	
Columbia needlegrass	5 to 10				
Elk sedge	10 to 15	1.50		7.0	
Idaho fescue	0 to 5				
Indian ricegrass	0 to 2				
Kentucky bluegrass	5 to 10			4.8	
Lettermann's needlegrass	5 to 10	.08		8.5	
Mountain brome	5 to 10	1.10		1.3	
Muttongrass	0 to 5				
Nodding bromegrass	2 to 5				
Showy oniongrass	0 to 2				
Prairie June grass	0 to 5				
Slender wheatgrass	5 to 10	3.10		2.3	
Thurber fescue	0 to 5				
Western wheatgrass	0 to 5				
Forbs					
American vetch	2 to 5				
Arrowleaf balsamroot	0 to 2	1.00		1.0	
Aspen peavine	2 to 5	1.40		1.6	
Pacific aster	0 to 2				
Mountain bluebells	0 to 1				
Common yampa	0 to 1				
Cow parsnip	0 to 2				
Nodding erigonom	0 to 1				
Oregon fleabane	2 to 5				
Richardson geranium	2 to 5				
Nettleleaf giant hyssop	0 to 2			.5	
Golden pea	0 to 2				
Louisiana sagewort	0 to 2				
Jacob's ladder	0 to 2				
Tall larkspur	0 to 2				
Silvery lupine	1 to 3	1.30		3.0	7.3
Fendler meadowrue	0 to 3				
Mulesears	0 to 2				
Northern bedstraw	0 to 2				
Rocky Mountain penstemon	0 to 2				
Drummond rockcress	0 to 1				
Showy cinquefoil	0 to 2				
Tuber starwort	0 to 1				
Timber poisonvetch	0 to 2			2.0	3.5
Western yarrow	2 to 5	1.80		1.7	
Trailing fleabane	2 to 5				
Duncecap larkspur	0 to 2				
Shrubs					
Antelope bitterbrush	0 to 2				
Common chokecherry	2 to 5	2.90			
Fendlerbrush	0 to 3				
Gambel oak	10 to 15	15.00	8.8	3.7	
Mountain big sagebrush	0 to 2				
True mountain mahogany	0 to 5				
Oregon grape	0 to 2				.4
Woods rose	0 to 5	1.30			
Saskatoon serviceberry	10 to 15	15.00	5.6	.8	
Silver sagebrush	0 to 2				
Mountain snowberry	2 to 5	5.00	20.5	5.0	29.3

Table 5
Identification of overly abundant species and invaders
Brushy Loam range site

	Transect No. 1 exceeded	Transect No. 2 exceeded
Identified increasers		
Tall rabbitbrush		
Knotweed	0.6	
Thistles		
Dandelion		
Tarweed		
Mullein		
Annual grasses		0.1
Annual forbs	3.5	3.4
Invaders		
Beggar ticks	2.3	6.6
Unknown composite	7.6	2.5
Showy goldeneye	.8	.6
Longleaf phlox	.4	.5
Aster		.8
Onion		.6
Total composition by transect of the species listed	99.6	99.1
Ecological seral-stage ration (percent)	49.5	44

Loamy Breaks (Dry Exposure) range site, transect in SW¼ sec. 5.

Foothill Swale No. 2, Straight Gulch, looking north from middle of transect.

contribute 40 to 70 percent of the production along with cushion-type forbs contributing up to 10 percent. Bluebunch and streambank wheatgrass, needle-and-thread, Indian ricegrass, June grass, and blue grama are important grasses in this range site. Low shrubs and forbs which are recognized for this range site are fringed sage, low rabbitbrush, phlox, buckwheat, daisy, globemallow, pussytoes, and loco.

The harshness of this site inhibits many invader plants. Following a severe disturbance, this site would be nearly barren to sparsely vegetated.

Survey information.--The transect taken on this range site indicated the area measured was in a fair seral stage of potential with an ecological seral-stage rating of 32.5 percent. The measured production of 791 pounds/acre on this site exceeded the potential in a favorable year by almost 300 pounds. Grasses comprised 43.9 percent, forbs made up 51.0 percent, and shrubs added 5.1 percent of the production. Bluebunch wheatgrass, lettermann's needlegrass, and Salina wildrye were the dominant grasses with stemless goldenweed, thistle, arrowroot, balsamroot, and loco contributing over half of the forb component.

The site appeared to be a less harsh exposure than other Dry Exposures occurring at higher elevations outside of the study area. The soils also appeared to be finer textured and more productive than the general description of the Dry Exposure range site. Table 6 lists the plants described for the Dry Exposures range site.

Foothill Swale

This community is typical of the valley bottoms primarily associated with perennial streams within the Collom Gulch study area. A high water table, alluvial aquifers, and overland flow from adjacent uplands provide additional moisture for vegetation biomass production. The soils are deep, well drained, and medium to moderately coarse textured. This range site contains 175.6 acres and comprises about 3.24 percent of the area. It occurs between 6,700 to 7,200 feet in elevation.

Two transects were taken within this range site--one in Morgan Gulch (sec. 5, NW¼NW¼) at about 7,040 feet and the second in Straight Gulch (sec. 33, NE¼SW¼) at about 6,880 feet in elevation. The second photograph on page 31 was taken at Foothill Swale transect No. 2 in Straight Gulch looking north. In the 1980 survey the transect in Morgan Gulch showed the production to be 2,564.4 pounds/acre (air-dry), and in Straight Gulch the production was 2,172.1 pounds/acre (air-dry). Vegetation cover was 74.7 percent and 41.3 percent, respectively.

Characteristic plant community.--This range site in northwestern Colorado is potentially a grassland plant community with a sparse stand of shrubs. Grasses that are expected to be present and the present composition they could potentially contribute are basin wildrye (50 percent), western (10 percent), streambank wheatgrass (10 percent), Indian ricegrass (5 percent), squirreltail (5 percent), and Nevada bluegrass (5

Table 6
Determination of ecological seral-stage rating and identification of overly abundant species and invaders
Dry Exposure range site

	Allowed	Exceeded
Potential plant community		
Bluebunch wheatgrass	15.0	6.9
Needle-and-thread	.8	
June grass	2.5	
Indian ricegrass	.3	
Streambank wheatgrass	2.7	
Thickspike wheatgrass		
Blue grama		
Winterfat	.8	
Fringed sage		
Douglass rabbitbrush	.2	
Globemallow, buckwheat, and hoods phlox	5.0	1.1
Pussytoes, mat loco, and nailwort	.2	
Others (stemless goldenweed)	5.0	11.2
Invaders		
Lettermann's needlegrass		8.1
Salina wildrye		3.5
Sandberg bluegrass		2.4
Penstemon, onion, and groundsel) Mustard and daisy)		4.8
Arrowleaf balsamroot		3.9
Astragalus		3.8
Thistle		11.9
Longleaf phlox and bastard toadflax		3.5
Big sage and horsebrush		3.7
Ecological seral rating	32.5	
Measured production not counted in rating		64.8
Measured production represented in this table, 97.3		

percent). Shrubs should include big sagebrush (10 percent), rubber rabbitbrush (5 percent), and fourwing saltbush (5 percent). The forbs that are expected to occur are yarrow, fleabane, globemallow, Indian paintbrush, wild buckwheat (all total = 10 percent), and herbaceous sage (1 percent).

The well established or historical invaders of the Foothill Swale plant community include cheatgrass, Kentucky bluegrass, thistle, lambsquarter, mustard, cactus, snakeweed, and greasewood.

Survey information.--A comparison of the SCS range site description with the two transects taken within the range site indicates that the area is in a low-good and high-fair seral stage with ecological seral-stage ratings of 46.0 percent and 50.4 percent, respectively. As expected, the transects indicate a large grass component of 52.2 percent and 60 percent in the Morgan and Straight Gulch Foothill Swale range sites, respectively. The forbs and shrub components, however, were more variable between the different transects. The Collom Gulch transect showed 31.4 percent forb component and 16.4 percent shrub component. The Morgan Gulch transect had less forbs with 3.0 percent composition and more shrub production with 37.0 percent composition. Rubber rabbitbrush was the dominant shrub in each survey with a minor contribution from big sagebrush. The important grasses were basin wildrye and western wheatgrass. Streambank and slender wheatgrass, June grass, mountain brome, and native bluegrasses comprise the remaining grass component. Table 7 lists the plants described for the Foothill Swale range site.

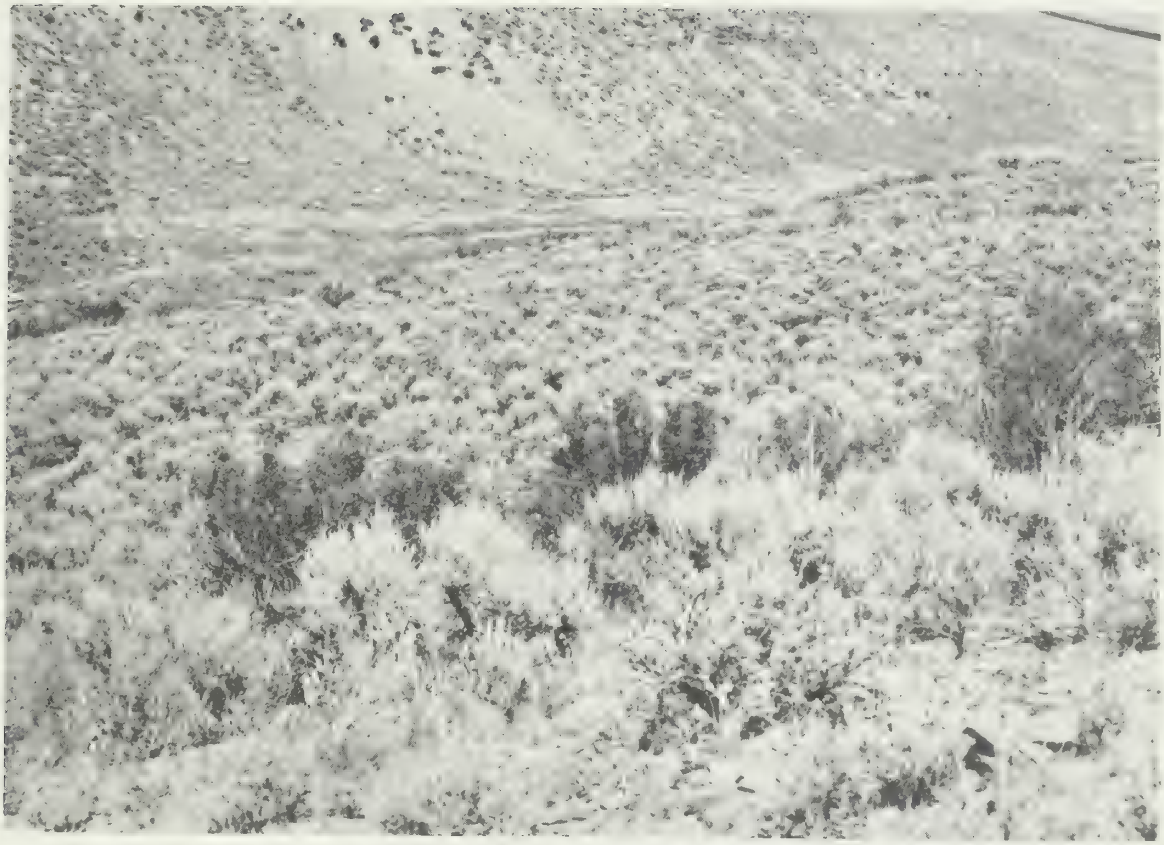
Loamy Breaks

This range site occupies canyon slopes and stony ridges primarily on dryer northwest exposures within the Collom Gulch study area. Slopes will range from 3 to 25 percent in steepness. The Loamy Breaks plant community is often associated in a complex with the Mountain Loam on uplands within the study area and most likely occurs within the Brushy Loam on the canyon walls. The soils are shallow, brown to dark grey-brown, and medium-textured loam or stony loam. Moderate permeability is characteristic of these soils; but, on steep slopes, potential soil moisture is reduced; thus the Loamy Breaks are characteristically droughty. This range site is found within the study area on 78.3 acres, comprising 1.45 percent of the area. The Loamy Breaks range in elevation from 6,720 feet to 7,100 feet in the study area.

One transect was taken on a northwest aspect in Straight Gulch (sec. 27, NW¼E½) at an elevation between 6,800 to 7,050 feet, as shown in the photograph on page 36. The data collected indicate the production to be 879.2 pounds/acre and the vegetation cover to be 43.3 percent.

Table 7
Determination of ecological seral-stage rating and identification of overly abundant species and invaders
Foothill Swale range site

	Morgan Gulch transect		Straight Gulch transect	
	Allowed	Exceeded	Allowed	Exceeded
Potential plant community				
Basin wildrye	24.3		22.2	
Western wheatgrass	6.2		10.0	19.50
Streambank wheatgrass	3.7			
Indian ricegrass			Trace	
Squirreltail			4.6	
Nevada bluegrass				
Slender wheatgrass	3.0	5.30		
Needle-and-thread				
Beardless bluebunch wheatgrass			.2	
Bluebunch wheatgrass	.4			
Sand dropseed				
Yarrow, bladder pod, fleabane, globemallow, and Indian paintbrush; Buckwheat	1.8		1.2	
Herbaceous sage			.2	
Big sage	1.6		7.0	
Rubber rabbitbrush	5.0	8.10	5.0	24.50
Invaders				
Cheatgrass		.17		1.50
Kentucky bluegrass		7.50		
Thistle		5.40		
Mustard		7.30		.06
Snakeweed				
Aster		15.50		1.40
Winterfat				.44
Mountain brome		.55		
Big bluegrass		.70		
Onion grass		.22		
Milkvetch		.86		
Snowberry		1.80		
June grass				.97
Crested wheatgrass				.41
Sandberg bluegrass				.46
Ecological seral rating	46.0		50.4	
Measured production not counted in rating		53.40		49.24
Measured production represented in this table	99.40		99.64	



Loamy Breaks #1, NW exposure looking downslope along transect.

Characteristic plant community.--Loamy Breaks characteristically are sparsely covered with shrubs and grass and expected to have an optimum ground cover of 20 percent. Bluebunch and western wheatgrass, native bluegrasses, needle-and-thread, June grass, and squirreltail are the important grasses. Shrubs recognized as filling a niche on these sites are antelope bitterbrush, mountain mahogany, and big and black sagebrush. A complement of forbs, such as arrowleaf balsamroot, buckwheat, lupine, loco, and stemless goldenweed are potentially present on this site. Introduced plant species are the main invaders. Optimum ground cover is about 20 percent.

Survey information.--The transect, taken on this site to describe the ecological condition of the Loamy Breaks within the study area, indicated a good seral stage with an ecological seral-stage rating of 58. Many of the important plant species were encountered. The measured production of 878.2 pounds/acre was equal to, or a little higher than, the expected production in a favorable year.

Total measured production was comprised of 23.7 percent grass, 41.1 percent forbs, and 35.2 percent shrubs. Native bluegrass, arrowleaf balsamroot, loco, stemless goldenweed, and big sage were the plants characteristic of this range site which are common to the Loamy Breaks in the Collom Gulch study area. Basin wildrye and snowberry are two species unrecognized in the description that comprises 15.5 percent of

the measured production. Table 8 lists a description of the plants in this range site.

Mountain Loam

This range site occurs on ridge crests, mountain sides, terrace fans, and valley positions on slopes of 3 to 25 percent. Mountain loams occur on ridge crests and moderate slopes in the Collom Gulch study area adjacent to Stony Foothills, Loamy Breaks, and Brushy Loam range sites. Mountain Loam intergrades and forms complex range sites with Loamy Breaks, and inclusions of Brushy Loam soil formations and vegetation occur within the Mountain Loam range site, depending on micro-environment (slope exposure).

Soils of the Mountain Loam are moderately deep to deep and well drained. Topsoil is brown to greyish brown loam to fine sandy loam. Subsoil is brown to reddish brown loam to clay loam. Permeability within the soil profile is moderate and the water-holding capacity is moderate to high. The amount of runoff and erosion will be affected by the degree of slope and directional exposure. Mountain Loams occupy 539.8 acres of the study area, comprising approximately 10 percent of the area.

The Mountain Loam-Loamy Breaks Complex is greater in extent. It is found on steeper slopes or at a lower elevation along ridges or hillsides. Soils are shallower than Mountain Loam soils; hence, water-holding capacity is reduced. The vegetation is similar to both range sites but more closely resembles the Mountain Loam plant community. This complex occurs on 1,214.5 acres or 22.4 percent of the Collom Gulch study area.

Three transects were taken within the Mountain Loam range site; however, the third transect was actually within the complex of Loamy Breaks. The first transect was taken on a gentle north to northeast-facing exposure west of Collom Gulch (sec. 34, NE$\frac{1}{4}$NW$\frac{1}{4}$) at an elevation of 7,300 feet. The second transect was obtained from a ridgetop between Straight and Morgan Gulches (sec. 33, NW$\frac{1}{4}$NE$\frac{1}{4}$) on a moderate northeast exposure at 7,210 feet, as shown in the first photograph on page 39. The third transect was taken west of Morgan Gulch (sec. 32, NW$\frac{1}{4}$NE$\frac{1}{4}$) at 7,320 to 7,400 feet in elevation on a moderate east- to northeast-facing slope. The first transect yielded 1,537.2 pounds/acre (air-dry) of forage, and vegetation cover was 42 percent. The second transect had less production with 793.8 pounds/acre and vegetation cover of 37.7 percent. The third transect on the Mountain Loam-Loamy Breaks Complex yielded 1,098.6 pounds/acre and had a vegetation cover of 43.7 percent.

Characteristic plant community.--The potential plant community on Mountain Loams is described as grass dominated with minor amounts of shrubs and forbs. Production is ideally composed of 55 to 60 percent grasses, 15 to 20 percent forbs, and 25 to 30 percent shrubs. The grasses that are expected to dominate this site require a favorable soil moisture regime and include Idaho, Arizona, and sheep fescue; lettermann's

Table 8
Determination of ecological seral rating and identification of overly abundant species and invaders
Loamy Breaks range site

	Allowed		Exceeded
Potential plant community			
Western wheatgrass	0.06		
Native bluegrasses	7.80		
Bluebunch wheatgrass	2.30		
Needle-and-thread			
Prairie June grass	.95		
Squirreltail	.20		
Buckwheat	Trace		
Arrowleaf balsamroot	5.00		12.10
Lupine	2.10		
Loco	5.00		3.86
Stemless goldenweed	5.00		1.10
Black and big sage	24.50		
Antelope bitterbrush			
Low rabbitbrush	2.90		
Mountain mahogany			
Grey horsebrush	.20		
Serviceberry	1.90		
Snakeweed	.05		
Invaders			
Basin wildrye			11.50
Snowberry			4.00
Utah sweetvetch			1.90
Western yarrow			1.50
Barberry			1.60
Groundsel			.85
Ecological seral rating	58.00		38.40
Measured production represented in this table		96.40	

Mountain Loam looking northeast from sampled area.

Stony Foothills No. 2, lower end (south end) of sampled (transect) area. Morgan Gulch Reservoir to the east.

and Columbia needlegrass; bearded and slender wheatgrass; and mountain brome and Parry oatgrass. Important forbs include arrowleaf balsamroot, aspen peavine, longleaf phlox, silvery lupine, sulfur buckwheat, and western yarrow. The shrubs expected to occur are mountain big sagebrush, snowberry, low rabbitbrush, and Saskatoon serviceberry. The likely invaders on this site include fanweed, mustards, knotweed, tall rabbitbrush, broom snakeweed, pinque, cheatgrass, slimstem muhly, and threeawn.

Survey information.--The transects obtained on the Mountain Loam range site within the Collom Gulch study area indicate the ecological potential described in the previous section is not present in the existing plant community. An ecological seral-stage rating was given to the first and second transects of 17.55 and 29.46 percent, respectively. This corresponds to a low and low-fair seral stage, explained by the lack of important characteristic grass species and a shrub composition of 61.5 and 42.0 percent in the first and second transects, respectively. A large component of annuals, especially in the first transect, is using the soil moisture with less efficiency than native grasses. These annuals are, however, well established and reduce the vigor of grass seedlings. Birds beak was the most significant annual, accounting for 17 percent of the production in the first transect and 11 percent in the second. The forbs added 24.9 and 42.8 percent to the measured production in the first and second transects. Grasses accounted for 13.5 and 15.2 percent, respectively.

The third transect within the Mountain Loam-Loamy Breaks Complex resembles the first and second transects with a large shrub component of 64.4 percent, small grass component of 9.7 percent, and a moderate forb component of 25.9 percent. A greater diversity of potential grasses and forbs characteristic of this range site was present, instead of a large component of annuals. The area the third transect represents was given a 26.0 percent ecological seral rating, corresponding to a low-fair seral stage.

Important plant species encountered were streambank, western and thickspike wheatgrass; sandberg bluegrass; squirreltail; arrowleaf balsamroot; lupine; milkvetch; big sage; and green rabbitbrush. Plant species contributing a smaller portion of the measured production, but still important for diversity, include Kentucky bluegrass, lettermann's needlegrass, mountain brome, June grass, slender wheatgrass, aster, longleaf phlox, and Lewis flax. A list of the plants described in this range site is presented in Table 9.

Stony Foothills

This range site in the Collom Gulch study area is on the drier, steep, southeast- and southwest-facing slopes. The degree of slope is generally 15 to 65 percent. This range site is situated on the steep canyon walls above the valley floors (Foothill Swale) and the moderately steep upland plant communities (Loamy Breaks and Mountain Loams) as illustrated in the second photograph on page 39. The north-facing slopes

Table 9
Determination of ecological seral rating and
identification of overly abundant species and invaders
Mountain Loam range site

Potential plant community	1 Allowed	1 Exceeded	2 Allowed	2 Exceeded	3 Allowed	3 Exceeded
Grass						
Arizona fescue						
Basin wildrye			Trace			
Bearded wheatgrass						
Big bluegrass	Trace					
Bluebunch wheatgrass						
Bottlebrush squirreltail	3.00	5.30	1.40		1.00	
Columbia needlegrass						
Elk sedge						
Idaho fescue						
Kentucky bluegrass			Trace		.50	
Lettermann's needlegrass			2.10		Trace	
Mountain brome					.06	
Mountain muhly						
Muttongrass	.09					
Nevada bluegrass					.36	
Nodding bromegrass						
Oniongrass			Trace		1.00	
Parry oatgrass						
Prairie June grass			.40		.30	
Sandberg bluegrass			1.60		.40	
Sheep fescue						
Slender wheatgrass					.07	
Thurber fescue						
Western wheatgrass	1.80		.80		.40	
Forbs						
American vetch					Trace	
Arrowleaf balsamroot			2.00	6.30	2.00	12.40
Aspen peavine						
Aster	.16				.18	
Bluebells						
Geranium						
Giant hyssop						
Herbaceous sage						
Indian paintbrush						
Lewis flax			Trace		.20	
Longleaf phlox			1.20		2.50	
Nineleaf biscuitroot					Trace	
Northern bedstraw						
Nuttall's sunflower						
Onion			1.00	.50	.60	
Rocky Mountain penstemon					Trace	
Rose pussytoes						
Silvery lupine	.30		5.00	11.40	1.40	
Showy cinquefoil						
Stoneseed						
Sulfur buckwheat						
Tailcup lupine						
Tall larkspur						
Timber poisonvetch	[illegible].00	2.56			.05	
Trailing fleabane			.50			
Western yarrow			.16			
Shrubs						
Antelope bitterbrush					Trace	
Common chokecherry						
Gambel oak						
Grey horsebrush					Trace	
Low rabbitbrush	.20		3.30		5.00	8.10
Mountain big sagebrush	10.00	5.07	10.00	28.80	10.00	41.40
Mountain snowberry			Trace			
Saskatoon serviceberry			Trace		Trace	
Silver sagebrush						
Wax currant						
Woods rose						
Recognized site invaders						
Fanweed						
Mustard		.10				
Knotweed				.25		.20
Tall rabbitbrush						
Broom snakeweed		.70				
Pinque						
Cheatgrass		1.50		.10		
Slimstem muhly						
Threeawn						
Other invaders						
Thickspike wheatgrass				8.50		Trace
Streambank wheatgrass		1.90		.30		5.10
Birds beak		17.00		11.40		Trace
Globemallow		.60		.15		
Agropyron saxicola						.60
Birdens spp.						.30
Hawks beard						1.00
Lupine hairy						3.60
Ecological seral rating	17.55	80.36	29.46	67.70	26.02	72.70
Measured production represented in this table	97.90		97.16		98.72	

opposite the Stony Foothills within the study area are either Brushy Loam or Loamy Breaks. The soils are medium textured, rocky, and are variable in depth from shallow to moderately deep. The variability of soil depth plays a role in determining the arrangement and composition of the plants on the landscape. This range site within the study area is found on 383.4 acres, comprising about 7.08 percent of the area. The Stony Foothills occur between 6,730 feet and 7,800 feet in elevation within the study area, but on southeast aspects the upper limit is 7,400 feet.

Two transects were taken within the Stony Foothills range site and both were on southeast-facing slopes. The first transect was in Collom Gulch (sec. 3, NW¼NE¼) between about 7,300 and 7,400 feet and the second was in Morgan Gulch (sec. 32, SW¼NE¼) between 7,000 and 7,200 feet in elevation. The inventory results for the Collom Gulch site gave 1,065.1 pounds/acre (air-dry) and 24 percent vegetation cover. The Morgan Gulch site yielded 872.3 pounds/acre with a total vegetation cover of 28 percent.

Characteristic plant community.--The ecological potential for the Stony Foothills indicates the Indian ricegrass, galleta, and western and bluebunch wheatgrass could contribute 45 to 64 percent of the total production in the understory. Native bluegrasses, needle-and-thread, June grass, and squirreltail would contribute from 5 to 17 percent. Forbs that are recognized in this range site are daisies, asters, buckwheat, goldenweed, phlox gilia, penstemon, and herbaceous sage and may be included for 0 to 12 percent of the total production. Pinyon pine and junipers are usually associated with the Stony Foothills but should not account for more than 5 to 10 percent of the understory production (production up to 4.5 feet in height).

Survey information.--The Stony Foothill transects differed widely in the grass, forbs, and shrub contribution to the measured production and also in the seral-stage rating. The Collom Gulch transect was given a 26.8 percent or low-fair and the Morgan Gulch transect was given a 58.4 percent or good ecological seral rating. These differences in rating can be explained by the excessive shrub component of 87.2 percent in Collom Gulch contrasted to 59 percent contributed by shrubs in Morgan Gulch. Grasses contributed 11.7 percent and forbs a low 1.1 percent to the measured production in Collom Gulch. In contrast, the Morgan Gulch Stony Foothill site had a much greater grass and forb composition with 29.8 percent and 11.2 percent, respectively. The survey indicated that bluebunch wheatgrass was the dominant grass, followed by streambank wheatgrass, Indian ricegrass, sandberg bluegrass, basin wildrye, muttongrass, and Salina wildrye. Important forbs included aster, phlox, herbaceous sage, mustards, globemallow, and onion. The shrubs differed slightly between the two transects. Big sage and serviceberry dominated on the Collom Gulch transect, whereas tall rabbitbrush and serviceberry were dominant in the Morgan Gulch survey, with lesser amounts of big sage, green rabbitbrush, snowberry, Gambel oak, and barberry. A list of plants described in the Stony Foothills range site is presented in Table 10.

Table 10
Determination of ecological seral-stage rating
Stony Foothill range site

	Collom Gulch transect		Morgan Gulch transect	
	Allowed	Exceeded	Allowed	Exceeded
Potential plant community				
Western wheatgrass) Streambank wheatgrass)	0.06		2.80	
Bluebunch wheatgrass	7.33		16.90	
Indian ricegrass	Trace		2.30	
Galleta				
Needle-and-thread				
Creeping wildrye				
Dryland sedges				
Other grass	1/3.60		2/5.00	2/1.40
Squirreltail	Trace			
Cheatgrass	.16		1.00	.40
Daisy				
Aster	.17		.30	
Buckwheat	Trace			
Goldenweed			Trace	
Phlox	.13		1.00	.30
Penstemon			Trace	
Herbaceous sage			1.00	.50
Cactus				
Other forbs	3/.80		4/5.00	4/1.54
Antelope bitterbrush	Trace			
Mountain mahogany	Trace		10.00	7.40
Mormon tea				
Black sage				
Big sage	5.00	40.10	1.10	
Fringed sagebrush				
Serviceberry	5.00	31.70	5.00	2.70
Curly-leaved rabbitbrush				
Tall rabbitbrush	2.00	.08	2.00	17.40
Other	5/2.60		6/5.00	6/6.40
Ecological seral rating	26.85	72.60	58.40	38.04
Measured production represented in this table	99.45		96.44	

1/ Basin wildrye, sandberg bluegrass.
2/ Salina wildrye, muttongrass, sandberg bluegrass.
3/ Onion, mustard.
4/ Globemallow, thistle, mustard, groundsel.
5/ Snowberry.
6/ Green rabbitbrush, snowberry, gambel oak, barberry.

Hydrology

Hydrologic data on the study site is inconclusive due to the complexity of the system; therefore, it is recommended that further data be obtained when funding allows.

A brief report on surface hydrology titled, Surface Water Hydrology of Coal Hydrology Study Site in Collom Gulch, Northwestern Colorado, is presented in Appendix G.

Limited information concerning the alluvial aquifers is attached in Appendix H as a USGS, WRD open file report titled, Water Levels and Water Quality in Alluvial Aquifers Near Collom Gulch, Moffat County, Colo.

Wildlife

The study area provides habitat for a variety of wildlife species. Big game inhabitating the area include elk and mule deer. Sage grouse were observed on the site. Aquatic and riparian habitat found along the streams and ponds provide nesting, roosting, and feeding habitat for waterfowl, songbirds, raptors, and many small nongame mammals and reptiles.

CHAPTER III

CONCLUSIONS AND RECOMMENDATIONS

Physical and Chemical Characteristics of Available Plant Growth Media

Soils

The naturally occurring soils of the Collom Gulch study site have few major problems relative to their potential use as a plant growth media. Their physical and chemical properties are generally good. Most of the surface layer textures are loam to clay loams. The subsoils are suitable at least to the 3-foot depth for all class 1 lands and most class 2 lands. The soils that are less than 8 inches deep or that were too steep to strip were designated as class 6 lands on the land classification maps.

Overburden materials

The overburden consists of sandstone, shale, and siltstone. Sandstone comprises approximately 45 percent of the overburden, shale 29 percent, siltstone 17 percent, and coal 9 percent. The sandstone varied from 35 to 56 percent of the overburden in the five drill holes, shale from 18 to 40 percent, siltstone from 11 to 33 percent, and coal from 5 to 14 percent. The coal seams varied in thickness from less than 1 foot to 12 feet.

Most of the geologic overburden material is of limited suitability or is unsuitable as topsoil. Drill hole 3 contained the most unsuitable overburden. Because of the limited or unsuitable characteristics of the overburden, it will be necessary to cover the raw overburden spoil with a topsoil dressing.

Qualities of Plant Growth Media and Overburden

The land classification study identified 2,352 acres of land that are suitable for use as plant growth media. There are 75 acres of class 1 lands that have a minimum strippable depth of 36 inches. Class 2 lands total 1,427 acres with a minimum strippable depth of 18 inches. There are 850 acres of class 3 lands with a minimum of 8 inches strippable depth. The class 3 lands are a limited source of plant media due to their shallow depth, steep slopes, or other deficiencies.

Most of the overburden will rapidly weather to silt- and clay-sized particles and form an adequate subsoil for revegetation. Considering the depth of the 2,352 acres of suitable soil, it is felt that there is sufficient soil or plant growth media to topdress the reshaped mine spoil with 6 or more inches of topsoil depth for revegetating the mined areas.

General Feasibility for Revegetation

The feasibility of reclamation of the poststrip-mined Collom Gulch study site is dependent upon many factors. One of the most important factors is the land use chosen for the postmining lands. Other factors include climate, topography, geology, hydrology, and soil.

The information gained in this study indicates there is a good possibility of reclaiming the land and returning it to its present land use. The climate is favorable--especially the annual precipitation pattern. A postmining topography should be chosen which will reduce the chance of land slips and reduce the runoff so more precipitation is available for establishing and sustaining revegetation. The unsuitable layers of overburden should be buried below 5 feet so it will not adversely affect the new plant life.

Nutrient deficiencies

Greenhouse studies and chemical analysis of selected soil and overburden samples indicate phosphorus and nitrogen deficiencies exist on most samples. Phosphate and nitrogen fertilizer applications can correct these deficiencies during revegetation. None of the trace elements appear to be deficient in the samples tested.

Climate and water

Variability of precipitation is an important constraint to successful revegetation. The following practices are recommended to ensure a greater possibility of reclamation of the study site.

1. Mulching or other methods of reducing the evaporation of available moisture.

2. Using catch basins, contour grading, and other methods to reduce or slow runoff and allow it to be absorbed by the soil.

3. Multiple seedings to increase the chances of a good stand of reestablished vegetation.

Recommendations for Reclamation to Suit Selected Postmining Use

Handling and placement of soil and overburden material

The land areas delineated as suitable or limited suitable (land classes 1, 2, and 3) for stockpiling, and ultimately as replaced topsoil, should be mechanically stripped and stockpiled in such a way as to minimize compaction and reduce wind and water erosion. During the stripping and stockpiling operation, care should be exercised so as to reduce contamination from unsuitable layers of both soil and overburden materials.

The overburden (bedrock) material should be removed and cast whenever possible so that the more unsuitable layers are buried deep, with the suitable and the limited suitable materials at or near the surface.

Since surface mining by its nature completely disturbs and displaces the original surface or topsoil, it is necessary to develop a suitable medium for plant growth if reclamation and revegetation are to be accomplished. Topsoil salvage and topdressing are a means of accomplishing this principle and are more acceptable and have more potential for success than the use of overburden materials. The use of overburden materials with satisfactory textural, chemical, and physical properties, coupled with a fertilization program, could provide the mechanical support and be suitable as a plant growth media.

Shaping of spoil for revegetation aesthetics and erosion control

To accomplish revegetation, surface manipulation of the spoil banks will be a reclamation requirement. This manipulation consists of modifying the spoil surface into configurations which facilitate postmined land use requirements and blends with the topography and contour of the overall area. To enhance revegetation, surface manipulation must also reduce erosion by reducing the rate and amount of surface runoff, thereby improving plant growth medium moisture conditions which will allow for the establishment of vegetative cover.

The cast spoil should be reshaped and topdressed with topsoil or suitable plant growth media. Revegetation should include vegetative species to conform with the natural ecosystem and the selected postmining land use.

Restoration of the rangelands and wildlife habitat, including badland areas disturbed by surface mining, will require a greater effort to retain the natural aesthetics of the area. Reshaped spoil banks will need to blend with the existing landscape and still insure slope stability, control erosion, and establish native vegetation.

Conservation measures needed to ensure erosion control

Control of erosion at the Collom Gulch site will be dependent upon the effective reestablishment of perennial vegetation. The method or methods of mechanical treatment used to establish vegetative cover include (1) treatments to effectively reduce surface runoff and improve water infiltration and (2) methods to increase and store soil moisture.

Methods to accomplish these objectives and enhance the vegetative succession include reshaped and contoured spoil banks, topsoil replacement, contour plowing or terracing, dozer basins, deep chiseling, pitting, ditching, listering or gouging, discing, and mulching. These treatments are not only effective in controlling surface runnoff but will also control wind erosion. They assist in conserving moisture by providing catchment basins for snow and runoff and also increase the infiltration rate.

Conservation to control erosion following the reestablishment of perennial vegetation will consist of management practices to control use of the area and establish a healthy plant community. These practices will include a fertilization program, irrigation when necessary, and fencing to control trespassing and grazing.

Selection of Species for Seeding

Regulations governing reclamation require a return of surface mined lands to approximately their natural state and revegetating with predominantly native plants. In a sense, this is an attempt to bypass the stages of secondary succession and produce a stable community.

The native vegetation as it occurred before mining, however, will not be a stable community on postmined land. The entire ecosystem of mined land has been disrupted, and changes have occurred from the microclimate to soils developing from different parent material. The scheme of reclamation, as it occurs today, stockpiles soils of several different plant communities. This soil is used to cover an area that supported several plant communities (before mining) with a uniform depth of soil. A mixture of predominantly native species is then seeded resulting in a single plant community being established where several occurred before mining. Through secondary succession, nature will establish a vegetative composition of specified plants adapted to the environmental conditions present following reclamation.

Seeding a native mixture to initiate a later stage of secondary succession on strip-mined land is probably the most stable community that can be established with present day knowledge.

The following list of plant species represents the native potential vegetation for the study site. This list should be used in developing a species mixture for revegetation on the study site.

Grasses	Forbs	Shrubs
Thickspike wheatgrass	Vetch	Sagebrush
Slender wheatgrass	Buckwheat	Rabbitbrush
Streambank wheatgrass	Balsamroot	Serviceberry
Western wheatgrass	Phlox	Bitterbrush
Bluebunch wheatgrass	Globemallow	Juniper
Sheep fescue	Lupine	Saltbush
Prairie June grass	Yarrow	Greasewood
Indian ricegrass	Aster	Shadscale
Sandberg bluegrass	Penstemon	Winterfat
Nevada bluegrass	Herbaceous sage	Fourwing saltbush
Squirreltail	Indian paintbrush	Snowberry
Needle-and-thread	Stoneseed	Horsebrush
Columbia needlegrass	Fleabane	Chokecherry
Lettermann's needlegrass	Hawksbeard	
Muttongrass	Gilia	
Basin wildrye		
Sand dropseed		
Galleta		

There are no identified endangered or threatened plant species on the study site or surrounding area.

Introduced species which have an adaptation to the area are listed below.

Whitmar wheatgrass	Volga wildrye
Siberian wheatgrass	Durar hard fescue
Crested wheatgrass	Prostrate summercypress
Critana wheatgrass	Vetch
Pubescent wheatgrass	Clover
Russian wildrye	

Reclamation efforts should be directed toward the development of diverse and self-perpetuating plant communities. Because of precipitation patterns of the area, those species which take advantage of early spring moisture, germinate early, and concentrate their growth during the early growing season offer the best choice for stable plant communities. Other considerations which should influence the selection of species for revegetation include (1) their natural adaptation for the area, (2) their ability to establish, (3) their ability to provide cover and soil stability, (4) their nutritional value and palatability for wildlife and domestic livestock, (5) their drought resistance, and (6) their disease resistance.

Seeding Methods

Any practice that would enhance natural revegetation should be initiated in the reclamation process. Plant material cleared from the premining area should be saved and incorporated in the resurfacing soil or used as a mulch. Plant material removal and topsoil removal should follow production of a seed crop. This will allow a seed crop to be stockpiled with the soil and plant material.

Transplanting pads of natural shrubby vegetation will provide a quick wildlife cover and enhance natural revegetation. This can be accomplished with the use of a front-end loader. Mature, healthy shrubs can also be transplanted with a tree spade. The front-end loader, however, can transplant more area and provide a greater variety of vegetation.

If a mulch is applied for improvement of soil characteristics, it should be incorporated into the soil before seeding. Adequate nitrogen must be available to break down the mulch. If fertilizers are used to increase soil nutrient levels or to break down soil additives, they should be incorporated into the soil before or during seeding.

Following placement of the plant growth media (topsoil), a seedbed should be prepared. The area to be seeded should be ripped or subsoiled to alleviate compaction by heavy equipment and to enhance water infiltration. The soil preparation should provide an even and firm seedbed to

allow regulation of uniform planting depth. Seed should be drilled on the contour or perpendicular to the slope. Most grass seed should be seeded to a depth of 1/2 to 3/4 of an inch. The depth placement of a seed is roughly proportional to its size. Small seed should be broadcast and seeded to a depth of 1/2 or 3/4 of an inch. This can be accomplished by allowing half the small seed to be planted in the grass seed furrow and the other half to be broadcast behind the drill with the minimal amount of cover provided by the drill drags. Large seeds, having a long germination period, should be seeded deeply enough to ensure a moisture supply during germination.

To enhance germination and obtain an established stand of grass, fall seeding is recommended. A rangeland or deep furrow drill should be used.

Bare-root stock or container-grown shrubs should be planted in the early spring. The use of bare-root or container-grown stock should be in conjunction with rodent and wildlife protection. To enhance establishment and growth of shrubs, they should be planted in areas that receive more effective moisture such as north slopes, areas of slow runoff, and areas that are protected from wind and have a low evapotranspiration ratio.

Surface Protection

As discussed in the land suitability section, sufficient topsoil or other acceptable plant growth media derived from lower soil layers or overburden are available for resurfacing the study site and regulations require a return to the natural state following mining. In this case, lack of root mass and loss of soil structure is perhaps the main difference separating revegetation following mining and revegetation following a burn. The problem will be essentially to hold the topsoil from erosion until sufficient vegetation cover can be developed.

Wind erosion decreases with the reduction of wind velocity hitting the ground. This reduction may be accomplished through surface roughness. A standing stubble or cover crop has proven the most effective surface roughness. A fast growing annual should be used as a cover crop and should either be a sterile hybrid or not be allowed to set viable seed. This will allow a quick cover and eliminate competition from the cover crop. Surface roughness can also be produced through tillage operations that form ridges or bring clods to the surface. The tillage operation should be at right angles to the prevailing wind. Applied mulch can also be an effective surface roughness treatment. To be effective, however, the mulch should be anchored to the soil surface.

Measures to control water erosion will also be necessary. Surface gouging, contour furrows, and drill furrows should be used for water retention and soil holding in an effort to minimize and control surface runoff and to add water to the soil profile. Sediment reservoirs or stock ponds could be used to help control runoff and water erosion. A cover crop or mulch used for surface stabilization against wind erosion would also be beneficial in controlling surface runoff.

Postmining Land Management

Proper postmanagement of the reclaimed area is essential if reclamation is to be successful. The reseeded area should be protected from grazing until vegetation is sufficiently developed and established to withstand grazing use without damaging the vegetative cover. Once established, a planned grazing system should be used to graze the area.

In the event weed growth prevents the likely survival of the seeded species during establishment, acceptable methods of weed control should be used. If noxious weeds invade the rehabilitation site, acceptable methods of removal should be used. Corrective measures should be taken to stop any erosion.

A portion of the precipitation runoff should be intercepted by reservoirs following reclamation. These impoundments will provide water for wildlife and livestock use.

A fertilizer program may need to be followed for several years to maintain an adequate fertility level in order to suport grazing of the newly reclaimed area.

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APPENDIX A

GEOLOGIC DATA
FOR
RECLAMATION EVALUATION
COLLOM GULCH STUDY SITE
FEDERAL COAL MANAGEMENT PROGRAM
COLLOM GULCH, COLO.

United States Department of the Interior
Bureau of Reclamation
Upper Colorado Region
Division of Design and Construction
Geology Branch

Report No. G-322

Field Work and Writing
by D. Grundvig

Reviewed by
Fred Thompson, Regional Geologist

February 1981

APPENDIX A

GEOLOGIC DATA

Introduction

The data included within this report were collected as part of the Bureau of Land Management's (BLM) Federal Coal Management Program study of the Collom Gulch site. The Federal Coal Management Program is an interagency and interdisciplinary approach to field data collection; analysis; and interpretation of soil, water, overburden, and energy resource data. It is the objective of this program to assure that adequate baseline data are collected and that lease stipulations are established for mined land reclamation.

The basic purpose of BLM's program is to determine if the selected site can be effectively reclaimed. During the course of the study, the major problems involved in reclaiming the area are identified, and necessary measures are proposed to establish the desired postmining conditions.

The purpose of the geology investigation is to identify, map, and describe the in-place geologic characteristics of this particular site. This includes obtaining core samples to use in overburden analysis and greenhouse studies. The data included in this report and reports from other agencies will be combined by the BLM to prepare the comprehensive document for the study area.

Location and Topography

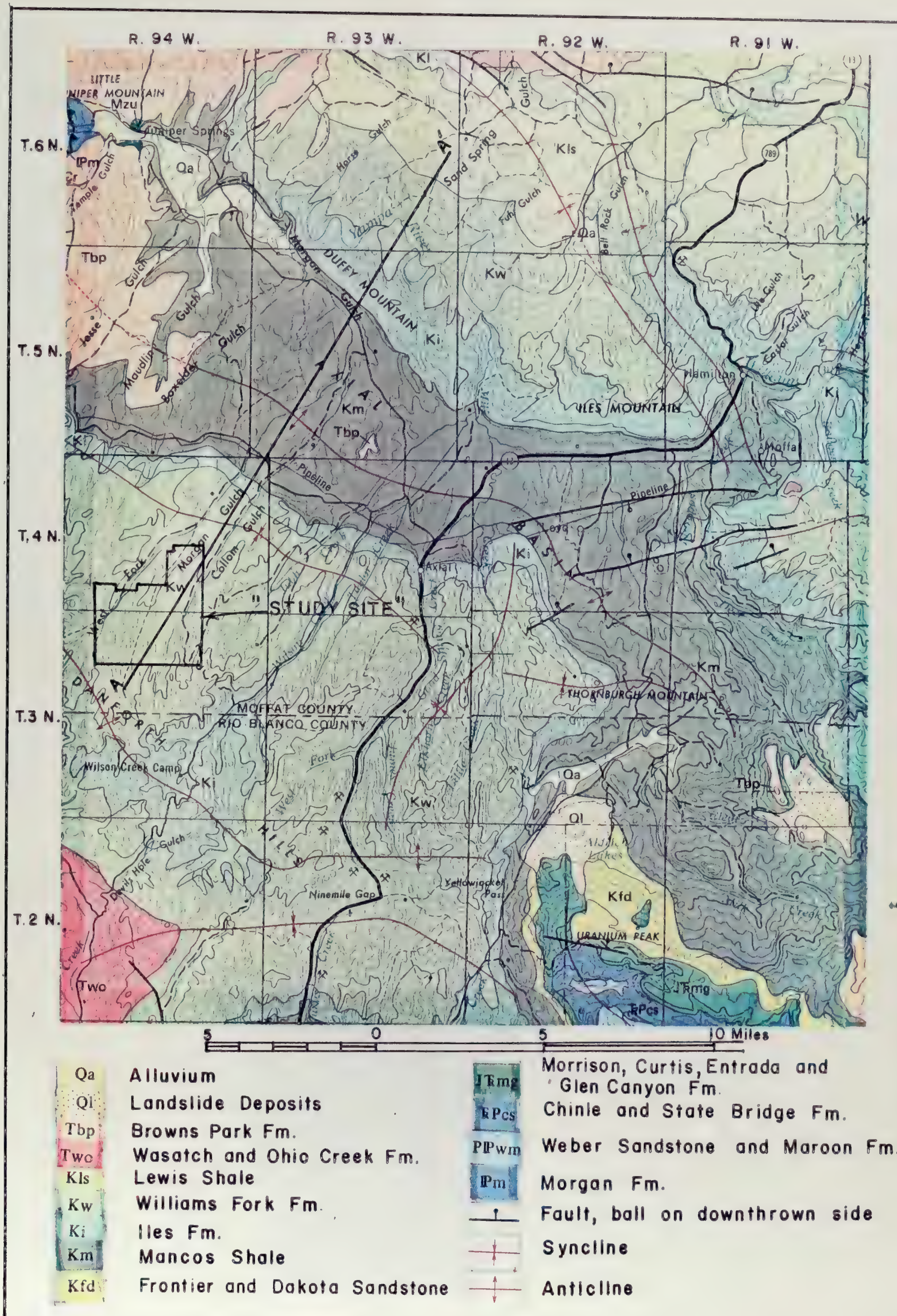
The Collom Gulch site is located in the northwest quarter of Colorado approximately 35 miles southwest of Craig. The study site is indicated on the Regional Geology Map, Figure 1 on the following page. Collom Gulch is immediately south of Axial Basin in the southern part of the Wyoming Basin Physiographic Province of the Rocky Mountain system.

The general area is characterized by long, gentle slopes which extend from the Danforth Hills northward to Axial Basin. (See the photograph on page 59.)

The area is drained mainly by parallel streams which head near the divide between the White and Yampa Rivers and flow northeastward into the Yampa. The general topography varies from steep canyons and gullies to gentle, northeastward dipping slopes. Elevations range from about 6,700 to 8,300 feet above sea level.

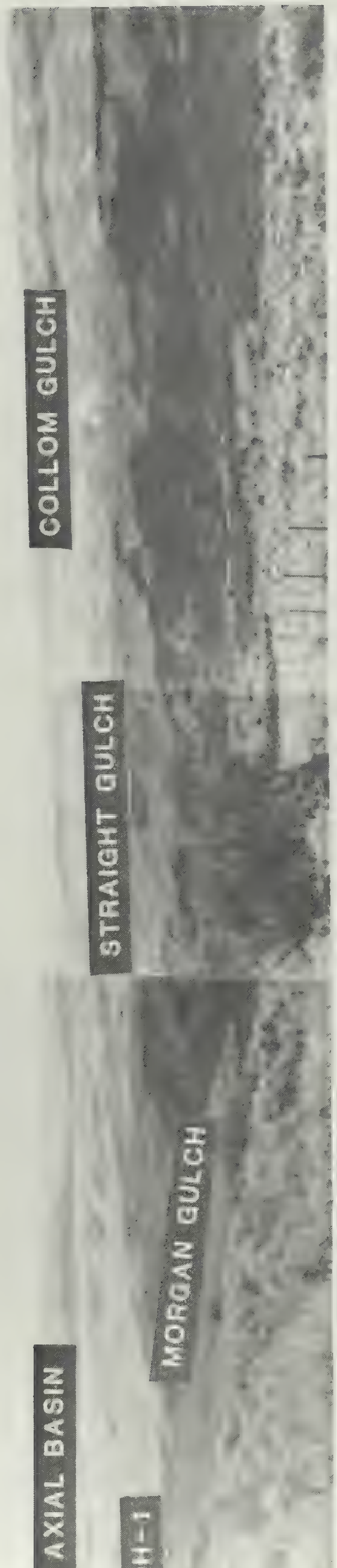
Regional Geology

The dominant structural feature of the area is the great uplift or arch known as the Axial Basin anticline. The anticline is believed to



REGIONAL GEOLOGY MAP

FIGURE 1



Panoramic view of study site taken from the southwest corner looking northeast toward Axial Basin.

be a southeastward extension of the larger Uinta Mountain uplift. The Axial Basin anticline is an asymmetrical fold with the dips on the south flank being much steeper than those on the north. The sandstones and shales which formed the crest of the anticline have been eroded away to expose the Cretaceous Mancos Shale (Km) in the center of the basin. Progressively younger rocks are exposed on the flanks of the fold and form a near-continuous escarpment which surrounds the basin. The axis of the anticline trends approximately N. 60° W. and extends from Little Juniper Mountain (T. 6 N., R. 94 W.) to Thornburgh Mountain (T. 3 N., R. 92 W.). A generalized structural section of the anticline is shown as section A-A' in Figure 2.

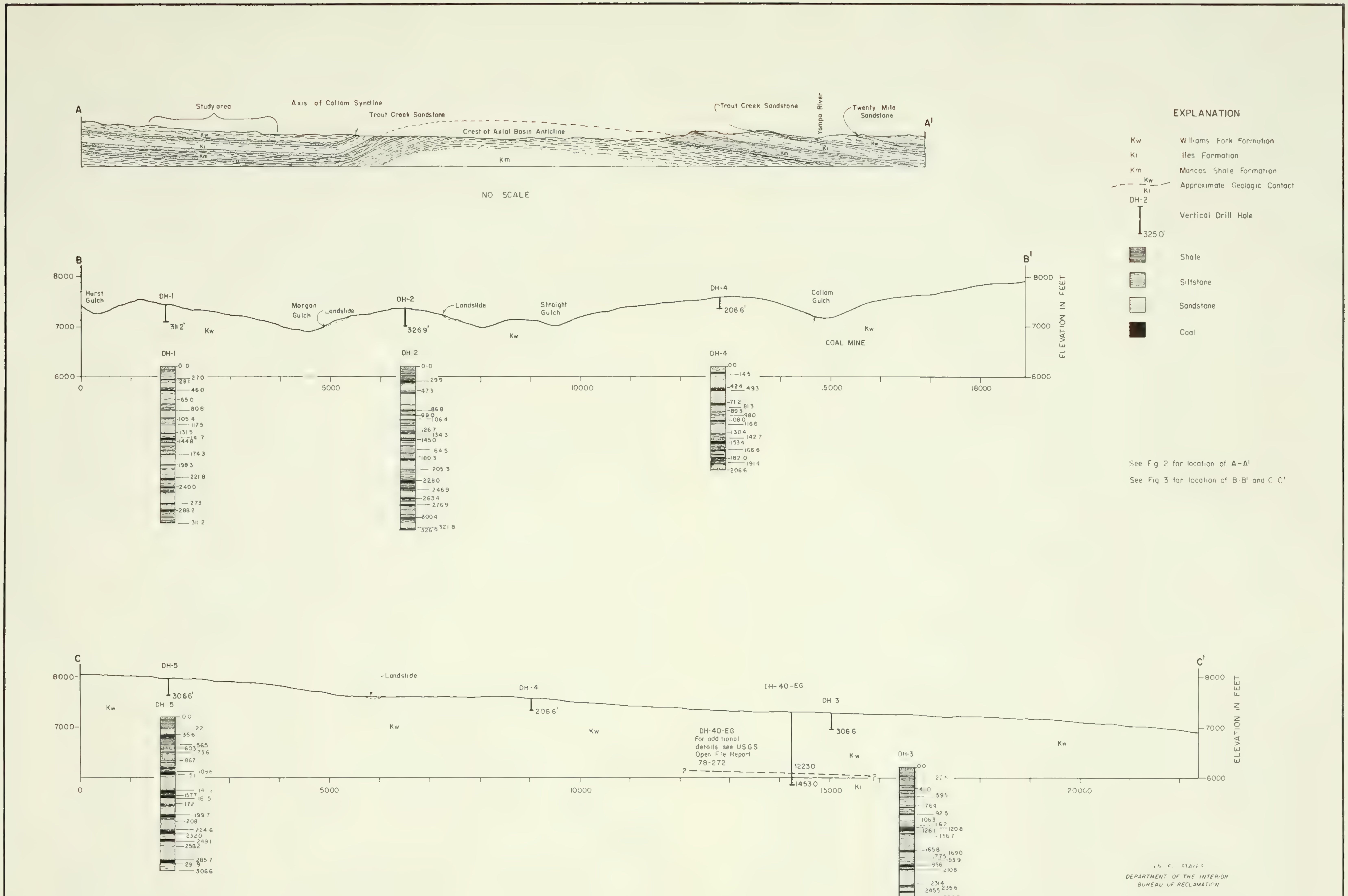
The south flank of the anticline forms the north flank of the Collom syncline. The axis of the syncline parallels that of the anticline and lies approximately 1 mile north of the study site. The syncline is also an asymmetrical fold with the beds on the north flank dipping more steeply than those on the south. Beds on the north flank dip 20° to 35° south, and beds on the south flank dip 8° to 20° north. Figure 1 shows the geologic formations and fold axis. The figure was adapted from the Geologic Map of the Craig 1° x 2° Quadrangle, Northwestern Colorado, U.S. Geological Survey (USGS) Map I-972.

Exposed rocks in the general vicinity of the study site are sedimentary in origin and Cretaceous and Tertiary in age. Exposed sequences include thick accumulations of sandstone, siltstone, shale, and coal. A generalized stratigraphic section of these sedimentary rocks is shown in Figure 3 on page 62 (Plate 18, USGS Bulletin 1027).

The Upper Cretaceous Mancos Shale (Km) underlies the study site at depth and is exposed north of the site in Axial Basin. Literature describes the unit as being approximately 4,600 feet thick and consisting of grey marine shale and interbedded sandstone in the uppermost part of the formation. The sandstone units are silty, very fine to fine grained, and generally thin bedded.

The Iles Formation (Ki) conformably overlies the Mancos and is exposed along the escarpment surrounding the basin. The formation is not exposed at the study site. The Iles is approximately 1,500 feet thick and consists of interbedded sandstone, shale, and coal beds. Its uppermost member, the Trout Creek Sandstone, separates the Williams Fork and Iles Formations and forms a prominent white ledge that can be traced for miles around the basin.

The Williams Fork Formation (Kw) is exposed over a broad region extending from the Danforth Hills, through the study site, and northward to the south rim of the Axial Basin. The formation is 1,100 to 2,000 feet thick and consists of interbedded sandstone, siltstone, shale, and coal beds. Two of the coal seams found in the middle portion of the unit, the Lennox and Wadge seams, are quite thick east of the study area and are of economic importance.



UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

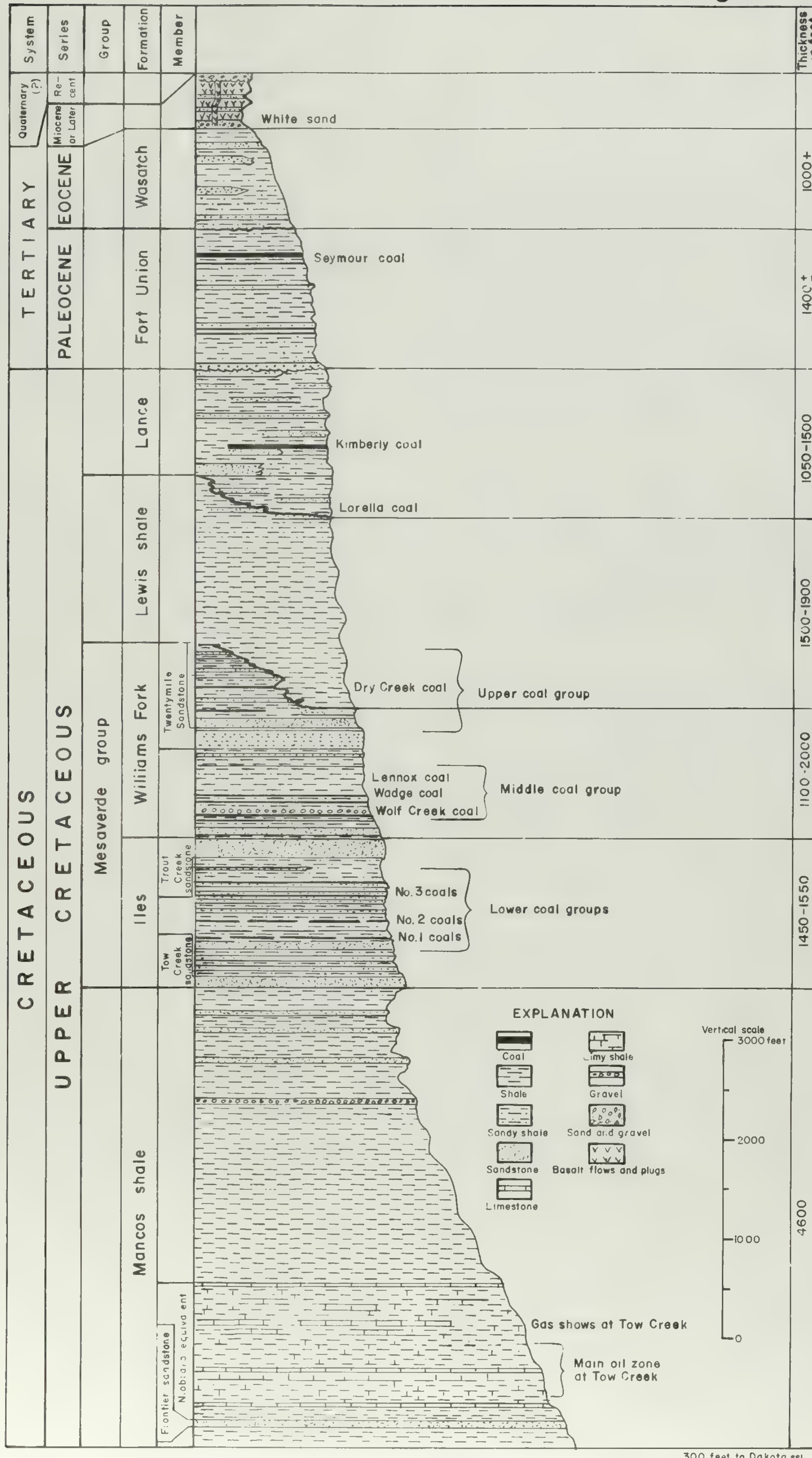
E.M.R.I.A. STUDY

COLLOM GULCH STUDY SITE

GEOLOGIC SECTIONS A-A', B-B', C-C'

FIGURE 2

Figure 3



GENERALIZED COLUMNAR SECTION OF EXPOSED ROCKS IN PARTS OF ROUTT AND MOFFAT COUNTIES, COLORADO

Investigations

Seven coal test holes were drilled within the study site boundaries by the USGS from 1976-78. The drilling was conducted as part of the USGS's continuing effort to evaluate the thickness and extent of federally owned coal in the Danforth Hills coal field. The seven holes were rotary drilled and geophysically logged. The drilling target in each of the holes was the Trout Creek Sandstone Member of the Iles Formation. Three of the holes were abandoned short of the target depth due to circulation problems. Depths ranged from 600 feet (DH-52-D) to 1,453 feet (DH-40-EG). Hole locations are shown in Figure 4 on the following page. For additional information, refer to USGS Open File Reports 78-272, -273, and -1031.

Geologic investigations were conducted in the study area by the Bureau of Reclamation between June and October 1980. These investigations included geologic mapping and drilling five core holes. Geologic mapping on a scale of 1-inch equals 2,000 feet was completed on aerial photographs and transferred to 7 1/2-minute quadrangle maps. The geologic data and drill hole locations are shown in Figure 4.

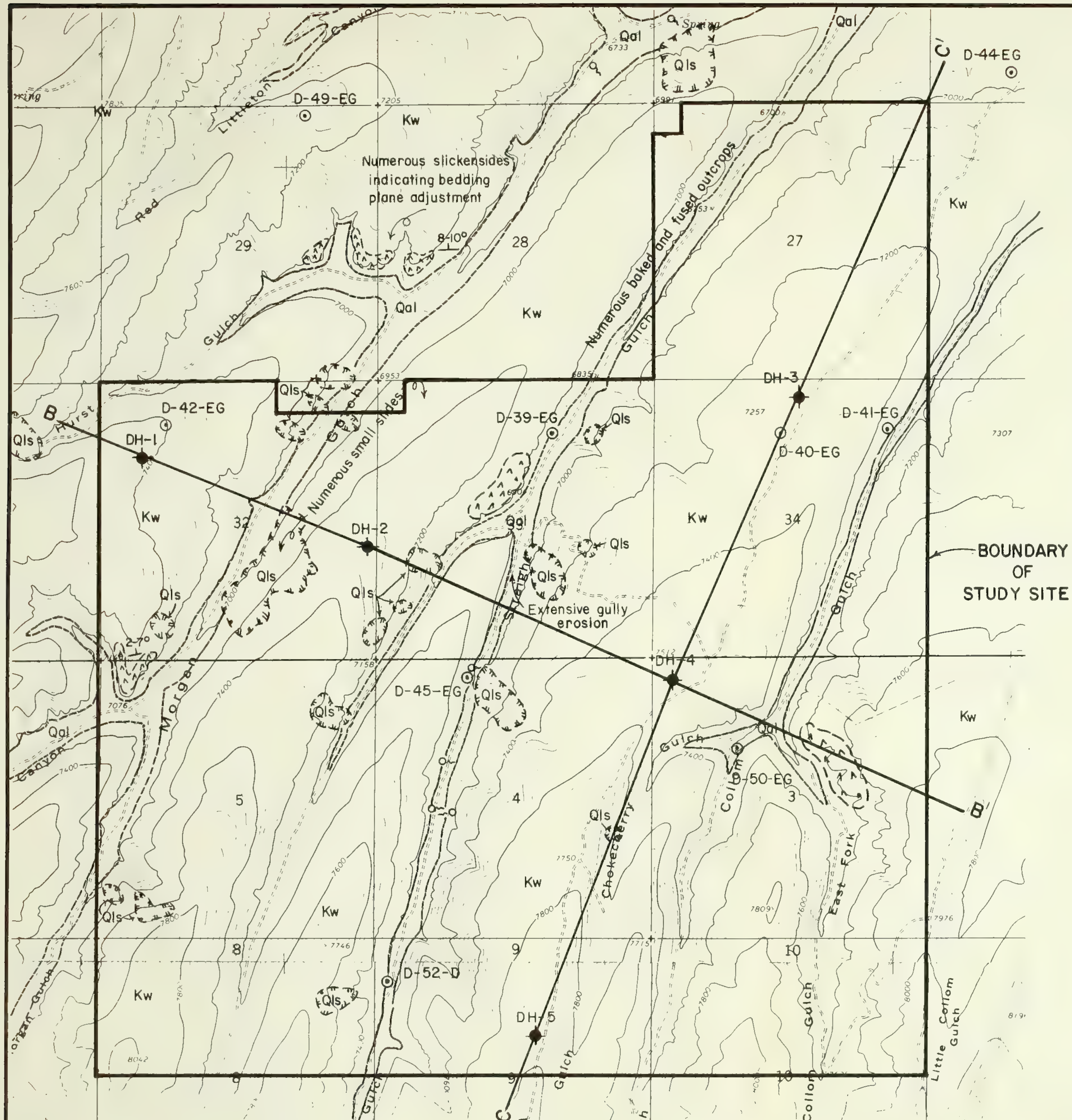
Five core holes, designated DH-1 through DH-5, were drilled at the Collom Gulch site. The purpose of the drill holes was to obtain samples of overburden for complete soil analysis. Drilling was completed with a skid-mounted Sprague and Henwood Drill, and core was recovered using HQ wireline equipment (2 1/2-inch-diameter sample). Water, obtained from local springs, was used as the drilling medium. Hole depths ranged from 206.6 feet (DH-4) to 326.9 feet (DH-2). The geologic logs of drill holes DH-1 through DH-5 are shown on pages 71 through 89.

Upon completion of the drilling, recovered materials were logged by USGS and Bureau of Reclamation personnel. The core samples were shipped to the Bureau of Reclamation Soils Laboratory in Salt Lake City for analysis. Selected coal samples were shipped to the USGS in Denver for determination of rank, Btu, and ash content.

At the completion of drilling, well points were installed at selected depths for ground water studies. These investigations are being conducted by the Water Resources Division of the USGS for the purpose of defining ground water systems in the coal mining regions of Colorado.

Site Geology

Clayey slopewash deposits cover much of the site to a depth of approximately 5 feet. Recovered core samples indicate that the site is underlain by interbedded very fine- to medium-grained sandstone, carbonaceous siltstone and shale, and coal of the Cretaceous Williams Fork Formation. For detailed lithologic descriptions, refer to the geologic logs. Outcrops of the Williams Fork occur primarily along canyon rims and are frequently baked and fused.



DESCRIPTION OF MAP UNITS

Qaternary

Qal — Alluvium: Unconsolidated material deposited by active streams, either perennial or intermittant; consists of silt and sand with some gravel, cobbles, and boulders.

Qls — Landslide: Unconsolidated soil and disrupted rock material deposited by mass movement down slope by gravity; consists of well to poorly sorted deposits of fines, sand, gravel, cobbles, boulders, and large rock masses.

UNCONFORMITY

Upper Cretaceous

Kw — Williams Fork Formation: Interbedded light brown to white sandstone, gray shale, and cool. Thickness 1,000-2,000 feet. Portions of the formation are characterized by thick zones of brick-red sandstone and baked shale produced by the natural burning of coal beds

Approximate Geologic Contact

Baked and Fused Strata

Landslide

Spring

DH-5 — W.P.R.S. Drill Hole

D-45-EG — U.S.G.S. Drill Hole

2-5° — Dip and Strike of Bedding

See Fig. 2 for location of A-A'

N.

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

E.M.R.I.A. STUDY

COLLOM GULCH STUDY SITE

SURFACE GEOLOGY AND LOCATION OF GEOLOGIC EXPLORATION

FIGURE 4

Coal was found in each of the five holes with thickness ranging from thin partings to an 11.5-foot-thick seam in DH-3. Average coal seam thickness encountered in drill holes DH-1 through DH-5 was 1.7 feet (10 seams), 1.5 feet (9 seams), 3.0 feet (11 seams), 2.2 feet (9 seams), and 4.4 feet (10 seams), respectively. Most of the seams were less than 3 feet thick. Only one other seam of significant thickness was found--a 10.7-foot-thick bed in DH-5. The Lennox and Wadge seams, found east of the study site, were not encountered during drilling but are believed to underlie the site at depth.

Throughout most of the study site, bedding planes strike approximately N. 75° to 80° E. and dip 2° to 10° north toward Axial Basin. The angle of the slopes follows closely the dip of the underlying rocks. The slopes are essentially stripped or structural planes and are produced by erosional stripping of a resistant layer. The base level of erosion coincides with the resistant beds.

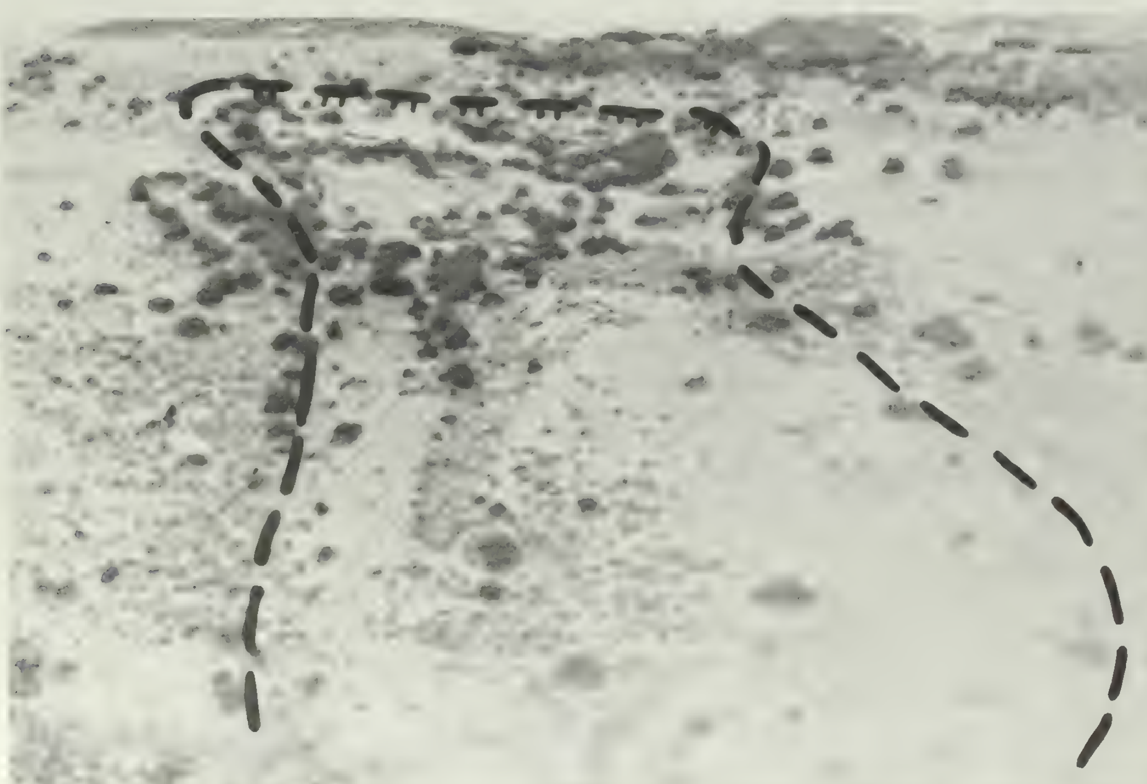
Although no significant faulting was identified during field investigations, frequent slickensides were found in some core intervals (usually in siltstone or shale) and in some outcrops. Most slickensides found in outcrops were near baked and fused strata and were oriented roughly parallel to bedding planes. Bedding plane adjustments could have resulted from either changes in volume of overburden after the burning of coal beds or from the large-scale folding which produced the Collom syncline and the Axial Basin anticline.

Numerous landslides, some quite large, were identified in and around the study site. Most were of the earthflow type but some were accompanied by slumping. The earthflows have formed on hillsides where materials possessing low inherent strength (surficial deposits, weathered siltstone, and shale) have become saturated and moved downslope. Many of the slides are associated with seeps and small springs. (See the photographs on the following page.)

Springs, discharging sufficient quantities for livestock use, are found in Morgan and Straight Gulches. Major springs are identified in Figure 4 on page 64. Flows ranged from less than 1 gallon per minute in Straight Gulch to approximately 40 gallons per minute in Morgan Gulch. In many cases, baked and fused sandstone outcrops were found immediately above the springs. It is believed that these springs are being fed by ground water moving downdip along bedding planes and through permeable "clinker" beds. In many coal fields, coal and clinker beds are the most permeable aquifers in the area but are of insufficient thickness for development of wells.

Landowners report that one of the springs in Straight Gulch may actually be an improperly abandoned drill hole. The "spring" issues from below the road in the valley bottom and sulfurous gasses bubble up in the water. No evidence of cuttings or surface disturbance was found near the spring.

View of landslide located near center of sec. 33 in Straight Gulch.



View of landslide located in the SW¼ of sec. 33 in the west fork of Straight Gulch.

Ground water was not encountered during drilling operations. In addition, drill hole instrumentation has, to date, shown the monitored intervals to be dry. See the geologic logs for the instrument locations on pages 71 to 89.

Postmining Conditions

Slope stability

Siltstone and shale of the Williams Fork Formation possess low, shear strength, especially when saturated. It is expected that slides could develop during mining, particularly along beds of weak plastic shale. Some siltstone and shale samples, recovered during core drilling, broke down readily when exposed to drill water and air. Saturation and slaking of cut slopes will increase potential instability. The potential instability of cut slopes and spoil piles will vary from mine to mine, requiring detailed engineering studies at each site.

Instability of the postmining landscape[1/]

Studies have shown that reclaimed coal mined areas in the region have experienced areawide settling, localized collapse, and piping. The severity of each of the conditions varies from mine to mine and is determined by the physical and chemical properties of the overburden and the methods and equipment used to contour the landscape.

Areawide settling is the most common and least disrupting condition to be expected in the postmining landscape. Settlement is most pronounced during the first year but decreases with time. Contoured spoils, consisting largely of coarse-textured or sandy overburden, experience less settlement than clayey overburden. Settlement is significantly less in scraper-contoured areas than in dozer-contoured areas because of the greater degree of compaction achieved by scraper-contouring operations.

Localized collapse generally occurs within a year of contouring and is more prevalent in areas that have been dozer contoured. Thawing of frozen spoil blocks, concentrated by midwinter contouring, generally results in local surface subsidence. This is less of a problem in areas that were scraper contoured because the large blocks of frozen spoil are broken apart, spread, and compacted.

Piping may be a severe and long-term problem at some localities and most commonly develops in areas contoured by dozers. Piping frequently develops on nearly flat surfaces where cracking has occurred, probably as a result of collapse or areawide settling. On such surfaces, runoff is minimal and the cracks allow large quantities of water to flow into the subsurface. Scraper-contoured areas usually are better compacted and have fewer avenues for infiltration of surface water.

1/ G. H. Groenwold and B. W. Rehm, 1980.

Ground Water

Aquifers which occur above the deepest coal seam to be stripped will be destroyed. Springs fed by ground water flowing along bedding planes or through clinker beds occurring above the seams to be mined will also be destroyed. Springs and seeps will probably not occur on hillsides of reclaimed land because the replaced spoil will not have the continuous bedding of the original sedimentary deposits.

Recharge of the ground water regime will depend upon the topography of the reclaimed land and the properties of the spoil. It is expected that initial permeability of the contoured spoil will be high due to the fractured state of the materials and the presence of voids. The spoil, however, contains large percentages of clayey fines; and, as settlement and weathering occurs, the reclaimed land will become less permeable. Aquifers which lie below the mined coal seams will not be disturbed by mining but may experience altered recharge as a result of mining and reclamation activities.

Conclusions and Recommendations

1. The study site is found within the Cretaceous Williams Fork Formation, which consists of alternating beds of fine-grained sandstone, siltstone, shale, and coal. Shear strength of the materials is generally low and slides may develop adjacent to cuts. In addition, slides involving saturated surficial deposits should be expected during mining operations.

2. Coal was found in each of the five drill holes. Seams ranged from thin partings to 11.5 feet thick. Most of the seams were less than 3 feet thick. The Lennox and Wadge seams were not encountered during drilling but are believed to underlie the site at depth.

3. Potential instability of reclaimed land may result from areawide settling, localized collapse, and piping. Studies indicate that use of scrapers to contour spoil may reduce the severity of settlement and piping.

4. Aquifers and springs which lie above the deepest stripped coal seam will be destroyed. Springs and seeps will probably not occur on hillsides of reclaimed land because the replaced spoil will not have the continuous bedding of the original deposit.

5. Initial permeability of spoil piles will be high but permeability will decrease as weathering and settlement occur.

DEFINITION OF TERMS

Aquifer:	A body of rock that contains sufficient saturated permeable material to conduct ground water and to yield significant quantities of ground water to wells and springs.
Clinker:	Masses of coal ash that are a byproduct of combustion.
Earthflow:	A landslide characterized by downslope movement of soil and weathered rock resembling a viscous fluid. Velocity ranges from slow to rapid.
Ground water:	That part of the subsurface water that is the zone of saturation. Loosely, all subsurface water as distinct from surface water.
Piping:	Erosion by percolating water in a layer of subsoil, resulting in caving and in the formation of narrow conduits, tunnels, or "pipes" through which soluble or granular soil material is removed.
Slump:	A landslide characterized by a shearing and rotary movement of a generally independent mass of rock or earth along a curved slip surface (concave upward). Characterized by a backward tilting of the mass with respect to the slope.
Stripped or structural plane:	An erosion surface developed during the mature stage of an erosional cycle in an area underlain by horizontal or gently inclined strata of unequal resistance, the overlying softer beds having been removed by erosion so as to expose the more or less smooth surface of a resistant stratum that has served as a local base level and thereby controlled the depth of erosion.

REFERENCES

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3. USGS, Miscellaneous Investigation Series Map I-972 (USGS Map of the Craig 1° by 2° Quad, Northwestern Colorado).

4. USGS Bulletin 757, Geology and Coal Resources of the Axial and Monument Butte Quadrangles, Moffat County, Colorado, by E. T. Hancock, 1925.

5. USGS Bulletin 812, Geology and Coal Resources of the Meeker Quadrangle, Colorado, by E. T. Hancock and J. B. Eby, 1929.

6. USGS Open-File Report 78-272, Drilling During 1977 in the Danforth Hills Coal Field, Easton Gulch and Devil's Hole Gulch Quadrangles, Moffat County, Colorado, by Marith J. Reheis.

7. USGS Open-File Report 78-273, Drilling During 1977 in the Danforth Hills Coal Field, Axial and Ninemile Gap Quadrangles, Moffat and Rio Blanco Counties, Colorado, by Constance J. Nutt.

8. USGS Open-File Report 78-1031, Drilling During 1978 in the Danforth Hills Coal Field, Easton Gulch, Devil's Hole Gulch, Axial and Ninemile Gap Quadrangles, Moffat and Rio Blanco Counties, Colorado, by Marith J. Reheis.

7-1337 (6-74)
Bureau of Reclamation

GEOLOGIC LOG OF DRILL HOLE

SHEET 1 OF 4

FEATURE Collom Gulch Study Site PROJECT Emria Coal Study STATE Colorado

HOLE NO. DH-1 LOCATION SW¼ NW¼, SEC. 32, T. 4 N., R. 94W. GROUND ELEV. 7440± 1/ DIP (ANGLE FROM HORIZ.) 90.0 degrees Down

COORDS. N. ... E. ...

BEGUN 08-25-80 FINISHED 09-12-80 DEPTH OF OVERBURDEN 3.5 feet TOTAL DEPTH 311.2 feet BEARING

DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED 187.0 feet 09-11-80 2/ LOGGED BY D. Grundvig LOG REVIEWED BY F. Thompson

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS	TYPE AND SIZE OF HOLE	CORE RECOVERY (%)	PERCOLATION TESTS: DEPTH (FEET) FROM (P, Cs, or Cm)	TO	LOSS (G.P.M.)	PRESSURE (P.S.I.)	LENGTH OF TEST (MIN.)	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	SAMPLES FOR TESTING	Driller: J. Dunn, B.O.R. CLASSIFICATION AND PHYSICAL CONDITION
								7440.0	0.0			

NOTE: 1/ All measurements are from ground surface. Hole was not surveyed, deviation (if any) from vertical is unknown.
PURPOSE OF HOLE: To obtain samples for determination of overburden properties.
DRILLING EQUIPMENT: Skid-mounted Sprague and Henwood.
DRILLING FLUID: water, recirculated.
DRILLING FLUID LOSSES: No water losses reported from 0.0 to 75.1'. 25 to 100% losses for the remainder of the hole.
CASING RECORD:

Cs Size (in.)	Depth of Cs (feet)	Hole Depth (feet)
-	-	10.1
4	10.1	10.1-311.2

HOLE COMPLETION: Geophysical logs were run in hole by U.S.G.S.
Well points were installed with tips at 135.0' and 224.8' (3' influence zones) for ground water studies.
No unusual drilling conditions, other than loss of drill water, were reported by driller.
2/Water level measurement on last day of drilling, probably does not represent water table.

Type and size of hole: HQ Wire-line (3½") (0–100 ft)

Percolation tests: NONE TAKEN

Depth interval (feet)	Core recovery (%)
0–10	0
10–15	88
15–25	92
25–35	82
35–45	93
45–55	87
55–65	100
65–75	92
75–85	100
85–95	95
95–100	95

Elevation (feet)	Depth (feet)
7436.5	3.5
7428.3	11.7
7427.8	12.2
7423.2	16.8
7421.3	18.7
7413.0	27.0
7411.9	28.1
7408.7	31.3
7402.9	37.1
7394.0	46.0
7392.5	47.5
7391.4	48.6
7390.7	49.3
7386.4	53.6
7380.5	59.5
7375.0	65.0
7370.7	69.3
7369.2	70.8
7368.5	71.5
7367.9	72.1
7367.4	72.6
7366.7	73.3
7363.8	76.2
7359.2	80.8
7340.0	100.0

0.0-3.5: Lean Clay: Approximately 70%, fines with medium plasticity, 30% fine sand, slight to moderate reaction with HCL, dark to light brown, dry. (CL)

3.5-311.2: Cretaceous Williams Fork Formation (Kw)
Interbedded sandstone, siltstone, shale, and coal. Individual units are described below.

Sandstone: principally quartzose but may be argillaceous in part, very fine to medium grained, subangular to subrounded grains, fresh to moderately weathered, weakly to well cemented, bedding indistinct, lightly jointed, black carbonaceous swirls and laminations in part, occassional slickensides, slight to moderate porosity, light gray to yellow brown, strong to no reaction with HCL. Core recovered in fragments to 3.3' lengths (most less than 1.5'). Most contacts are gradational.

Siltstone: carbonaceous and sandy in part, frequent shale partings, fresh to moderately weathered, moderately hard, moderately well cemented, indistinct bedding, lightly jointed, occasional near-vertical fractures and slickensides, gray to yellow brown, frequent leaf imprints, slight to strong reaction with HCL. Core recovered in 0.1' to 0.8' lengths. Most breaks are inclined approximately 10 degrees to the horizontal with rough, irregular surfaces. Most contacts are gradational.

Shale: carbonaceous and sandy in part, fresh to moderately weathered, slight to moderate air slaking, fissility poorly to moderately developed. Occasional slickensides, gray to black, slight to no reaction with HCL. Core recovered in fragments to 0.3' lengths. Most contacts are gradational.

EXPLANATION

CORE LOSS / CORE RECOVERY

Fe=oxides of iron, i.e. limonite and hematite
HCL=hydrochloric acid (10% solution)

Type of hole .... D = Diamond, H = Haystellite, S = Shot, C = Churn
Hole sealed .... P = Packer, Cm = Cemented, Cs = Bottom of casing
Approx. size of hole (X-series) .. Ex = 1-1/2", Ax = 1-7/8", Bx = 2-3/8", Nx = 3"
Approx. size of core (X-series) .. Ex = 7/8", Ax = 1-1/8", Bx = 1-5/8", Nx = 2-1/8"
Outside dia. of casing (X-series). Ex = 1-13/16", Ax = 2-1/4", Bx = 2-7/8", Nx = 3-1/2"
Inside dia. of casing (X-series) .. Ex = 1-1/2", Ax = 1-29/32", Bx = 2-3/8", Nx = 3"

7-1337 (6-74)
Bureau of Reclamation

GEOLOGIC LOG OF DRILL HOLE

SHEET 2 OF 4

FEATURE Collom Gulch Study Site PROJECT Emria Coal Study STATE Colorado
HOLE NO DH-1 LOCATION SW¼ NW¼, SEC.32, T.4 N., R. 94W. GROUND ELEV. 7440± DIP (ANGLE FROM HORIZ.) 90.0degrees Down
COORDS. N. .... E. ....
BEGUN 08-25-80 FINISHED 09-12-80 DEPTH OF OVERBURDEN 3.5' TOTAL DEPTH 311.2' BEARING ....
DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED 187.0' 09-11-80 2/ LOGGED BY D. Grundvig LOG REVIEWED BY F. Thompson

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS	TYPE AND SIZE OF HOLE	CORE RECOVERY (%)	PERCOLATION TESTS: DEPTH (FEET) FROM (P, Cs, or Cm)	TO	LOSS (G.P.M.)	PRESSURE (P.S.I.)	LENGTH OF TEST (MIN.)	ELEVATION (FEET)	DEPTH (FEET)
								73400	100.0
	HQ Wire-line (3½")	95		NONE TAKEN				7334.6	105.4
								7334.2	105.8
	110	96						7330.1	109.9
								7322 5	117.5
	120	100							
	130	96						7308.5	131.5
								7307.9	132.1
								7305.1	134.9
	140	96						7298.3	141.7
		100						7295.2	144.8
								7293.0	147.0
								7291.3	148.7
	150	82						7289.3	150.7
								7288.1	151 9
								7287.3	152.7
		74						7281.9	158 1
	160							7279.8	160.2
		100							
								7272.5	167.5
	170	100						7270.8	169.2
								7269.6	170.4
								7265.7	174 3
	180	95							
	190 HQ Wire-line (3½")	20							
		50						7241.7	198.3
								7240.0	198.7
									200.0

GRAPHIC LOG | SAMPLES FOR TESTING

CLASSIFICATION AND PHYSICAL CONDITION

Coal: dull to shiny black, mostly recovered in fragments less than 0.1'. Frequent, thin carbonaceous shale partings.

3.5 - 11.7: Shale
11.7 - 12.2: Siltstone; yellow brown, abundant Fe staining.
12.2 - 16.8: Shale
16.8 - 18.7: Siltstone
18.7 - 27.0: Shale
27.0 - 28.1: Coal
28.1 - 31.3: Shale
31.3 - 37.1: Sandstone; Fe-stained, near-vertical fracture at 33.3'.
37.1 - 46.0: Shale
46.0 - 47.5: Coal
47.5 - 48.6: Shale
48.6 - 49.3: Siltstone; slickenside inclined approximately 35 degrees to the horizontal at 49.2.
49.3 - 50.0: Coal
50.0 - 53.6: Sandstone
53.6 - 59.5: Siltstone
59.5 - 65.0: Sandstone
65.0 - 69.3: Siltstone
69.3 - 70.8: Sandstone
70.8 - 71.5: Shale
71.5 - 72.1: Siltstone
72.1 - 72.6: Sandstone
72.6 - 73.3: Siltstone
73.3 - 76.2: Shale
76.2 - 80.8: Siltstone
80.8 - 105.4: Sandstone
105.4 - 105.8: Shale
105.8 - 109.9: Sandstone; minor shale partings.
109.9 - 117.5: Siltstone
117.5 - 131.5: Sandstone; slickensides inclined 15 degrees to the horizontal, at 128.6'and 128.8'.
131.5 - 132.1: Coal
132.1 - 134.9: Sandstone
134.9 - 141.7: Siltstone
141.7 - 144.8: Coal
144.8 - 147.0: Siltstone
147.0 - 148.7: Shale; air slakes readily.
148.7 - 150.7: Sandstone
150.7 - 151.9: Shale
151.9 - 152.7: Siltstone
152.7 - 158.1: Sandstone
158.1 - 160.2: Shale
160.2 - 167.5: Sandstone; minor amounts of pyrite on some breaks.
167.5 - 169.2: Shale
169.2 - 170.4: Sandstone
170.4 - 174.3: Shale
174.3 - 198.3: Sandstone

EXPLANATION

CORE LOSS
CORE RECOVERY

Type of hole .... D = Diamond, H = Haystellite, S = Shot, C = Churn
Hole sealed .... P = Packer, Cm = Cemented, Cs = Bottom of casing
Approx. size of hole (X-series) . . Ex = 1-1/2", Ax = 1-7/8", Bx = 2-3 8", Nx = 3"
Approx. size of core (X-series) . . Ex = 7/8", Ax = 1-1/8", Bx = 1-5/8", Nx = 2-1 8"
Outside dia. of casing (X-series). Ex = 1-13/16", Ax = 2-1/4", Bx = 2-7/8", Nx = 3-1/2"
Inside dia. of casing (X-series) . . Ex = 1-1/2", Ax = 1-29 32", Bx = 2-3/8", Nx = 3"

FEATURE Collom Gulch Study Site PROJECT Emria STATE Colorado SHEET 2 OF 4 HOLE NO. DH-1

☆ GPO 679-482

7-1337 (6-74)
Bureau of Reclamation

GEOLOGIC LOG OF DRILL HOLE

SHEET 3 OF 4

FEATURE Collom Gulch Study Site PROJECT Emria Coal Study STATE Colorado

HOLE NO. DH-1 LOCATION SW¼, NW¼, SEC.32, T.4N., R. 94W. GROUND ELEV. 7440± DIP (ANGLE FROM HORIZ.) 90.0degrees Down

COORDS. N. E.

BEGUN 08-25-80 FINISHED 09-12-80 DEPTH OF OVERBURDEN 3.5' TOTAL DEPTH 311.2' BEARING

DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED 187.0' 09-11-80 2/ LOGGED BY D. Grundvig LOG REVIEWED BY F. Thompson

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS:

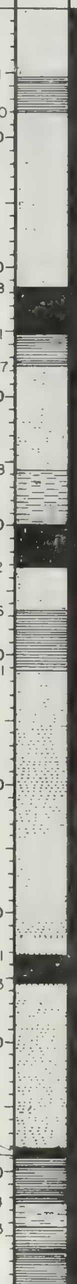
TYPE AND SIZE OF HOLE: HQ Wire-line ($3\frac{1}{2}$") (from 200 to 290); HQ Wire-line ($3\frac{1}{2}$") (from 290)

PERCOLATION TESTS (DEPTH (FEET) FROM (P, Cs, or Cm) / TO; LOSS (G.P.M.); PRESSURE (P.S.I.); LENGTH OF TEST (MIN.)): NONE TAKEN

Core recovery (%)
68
100
100
89
100
90
95
89
100
100
100
100

ELEVATION (FEET)	DEPTH (FEET)
7240.0	200.0
7234.9	205.1
7232.0	208.0
	210
	220
7218.2	221.8
7214.9	225.1
	227.7
	230
7204.2	235.8
7200.0	240
7196.8	243.2
7193.4	246.6
	250
7188.9	251.1
	260
	270
7166.9	273.1
7164.7	275.3
	280
7151.8	288.2
7151.2	288.8
	290
7147.6	292.4
7145.7	294.3
7140.0	300.0

GRAPHIC LOG



SAMPLES FOR TESTING

CLASSIFICATION AND PHYSICAL CONDITION

198.3 - 198.7: Coal; shale parting at 198.7.
198.7 - 205.1: Sandstone
205.1 - 208.0: Shale
208.0 - 221.8: Sandstone
221.8 - 225.1: Coal
225.1 - 227.7: Shale
227.7 - 235.8: Sandstone; high angle fracture from 230.7 to 231.5 - surface is rough, irregular and free of secondary mineralization.
235.8 - 240.0: Siltstone
240.0 - 243.2: Coal
243.2 - 246.6: Sandstone
246.6 - 251.1: Shale
251.1 - 273.1: Sandstone
273.1 - 275.3: Coal
275.3 - 288.2: Sandstone
288.2 - 288.8: Coal
288.8 - 292.4: Shale
292.4 - 294.3: Siltstone; slickensides inclined 45-60 degrees to the horizontal, at 289.1, 289.3, and 289.7. Near-vertical fracture with rough, irregular surface at 293.9'.
294.3 - 302.0: Shale
302.0 - 306.6: Sandstone
306.6 - 311.2: Shale

EXPLANATION

CORE LOSS

CORE RECOVERY

Type of hole . . . . D = Diamond, H = Haystellite, S = Shot, C = Churn
Hole sealed . . . . P = Packer, Cm = Cemented, Cs = Bottom of casing
Approx. size of hole (X-series) . . Ex = 1-1/2", Ax = 1-7/8", Bx = 2-3/8", Nx = 3"
Approx. size of core (X-series) . . Ex = 7/8", Ax = 1-1/8", Bx = 1-5/8", Nx = 2-1/8"
Outside dia. of casing (X-series) . Ex = 1-13/16", Ax = 2-1/4", Bx = 2-7/8", Nx = 3-1/2"
Inside dia. of casing (X-series) . . Ex = 1-1/2", Ax = 1-29/32", Bx = 2-3/8", Nx = 3"

FEATURE Collom Gulch Study Site PROJECT Emria STATE Colorado SHEET 3 OF 4 HOLE NO. DH-1

☆GPO 679-482

7-1337 (6-74)
Bureau of Reclamation

GEOLOGIC LOG OF DRILL HOLE

SHEET 4 OF 4

FEATURE Collom Gulch Study Site PROJECT Emria Coal Study STATE Colorado

HOLE NO DH-1 LOCATION SW¼ NW¼, SEC. 32, T. 4 N., R. 94W. GROUND ELEV. 7440± DIP (ANGLE FROM HORIZ.) 90.0 degrees Down

COORDS. N. E.

BEGUN 08-25-80 FINISHED 09-12-80 DEPTH OF OVERBURDEN 3.5' TOTAL DEPTH 311.2' BEARING

DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED 187.0' 09-11-80 2/ LOGGED BY D. Grundvig LOG REVIEWED BY F. Thompson

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS	TYPE AND SIZE OF HOLE	CORE RECOVERY (%)	PERCOLATION TESTS DEPTH (FEET) FROM (P, Cs, or Cm)	TO	LOSS (G.P.M.)	PRESSURE (P.S.I.)	LENGTH OF TEST (MIN.)	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	SAMPLES FOR TESTING	CLASSIFICATION AND PHYSICAL CONDITION
								7140.0	300.0			
	HQ Wire line (3½")	100		NONE	TAKEN			7138.0	302.0			
		100						7133.4	306.6			
	310								310			
			TOTAL		DEPTH	311.2'		7128.8	311.2			

EXPLANATION

CORE LOSS

CORE RECOVERY

Type of hole . . . . D = Diamond, H = Haystellite, S = Shot, C = Churn
Hole sealed . . . . P = Packer, Cm = Cemented, Cs = Bottom of casing
Approx. size of hole (X-series) . . Ex = 1-1/2", Ax = 1-7/8", Bx = 2-3/8", Nx = 3"
Approx. size of core (X-series) . . Ex = 7/8", Ax = 1-1/8", Bx = 1-5/8", Nx = 2-1/8"
Outside dia. of casing (X-series) . Ex = 1-13/16", Ax = 2-1/4", Bx = 2-7/8", Nx = 3-1/2"
Inside dia. of casing (X-series) . . Ex = 1-1/2", Ax = 1-29/32", Bx = 2-3/8", Nx = 3"

FEATURE Collom Gulch Study Site PROJECT Emria STATE Colorado SHEET 4 OF 4 HOLE NO. DH-1

GPO 679-482

7-1337 (6-74)
Bureau of Reclamation

GEOLOGIC LOG OF DRILL HOLE

SHEET 1 OF 4

FEATURE Collom Gulch Study Site PROJECT Emria Coal Study STATE Colorado

HOLE NO. DH-2 LOCATION NE¼, SE¼, SEC.32 T.4 N., R. 94W. GROUND ELEV. 7335' ± 1/ DIP (ANGLE FROM HORIZ.) 90.0 degrees Down

COORDS. N. .... E. ....

BEGUN 09-13-80 FINISHED 09-22-80 DEPTH OF OVERBURDEN 6.0' TOTAL DEPTH 326.9' BEARING ....

DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED Not Measured LOGGED BY D. Grundvig LOG REVIEWED BY F. Thompson

Driller: J. Dunn, B.O.R.

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS

NOTE: 1/
All measurements are from ground surface. Hole was not surveyed, deviation (if any) from vertical is unknown.

PURPOSE OF HOLE:
To obtain samples for determination of overburden properties.

DRILLING EQUIPMENT:
Skid-mounted Sprague and Henwood.

DRILLING FLUID:
Water, recirculated.

DRILLING FLUID LOSSES:
Driller reports no water losses from 0.0 to 58.0, 100% loss from 58.0 to 326.9.

CASING RECORD:

Cs Size (inch)	Depth of Cs (feet)	Hole Depth (feet)
-	-	24.1
4.0	20.0	24.1-31.1
4.0	30.0	31.1-326.9

HOLE COMPLETION:
Geophysical logs were run in hole by U.S.G.S.
Well points were installed with tips at 193.0' and 214.9'. Length of influence zones not reported by driller.

No unusual drilling conditions were reported by driller.

TYPE AND SIZE OF HOLE

4½" RB (0–24.1)
HQ wire-line (3½") (24.1–81.9)
HQ wire-line (3½") (from 81.9)

CORE RECOVERY (%)

0, 100, 80, 90, 100, 100, 40, 0, 100, 60, 64

PERCOLATION TESTS

NONE TAKEN

Driller reports sample washed away (approx. 80.0)

ELEVATION (FEET) / DEPTH (FEET)

Elevation (feet)	Depth (feet)
7335	0.0
7329.0	6.0
7305.1	29.9
7304.1	30.9
7303.5	31.5
7287.7	47.3
7282.4	52.6
7260.2	74.8
7259.5	75.5
7248.2	86.8
7247.7	87.3
7236.0	99.0
7235.0	100.0

CLASSIFICATION AND PHYSICAL CONDITION

0.0 - 6.0: Lean Clay: Approximately 70% fines with medium plasticity, 30% fine sand, slight to moderate reaction with HCL, dark to light brown, dry.(CL)

6.0 - 326.9: Cretaceous Williams Fork Formation (Kw)
Interbedded sandstone, siltstone, shale and coal. Individual units are described below.

Sandstone: principally quartzose but may be argillaceous in part, very fine to medium grained, subangular to subrounded grains, fresh to moderately weathered (mostly fresh), weakly to well cemented (mostly moderately cemented), bedding indistinct, lightly jointed, frequent black, carbonaceous swirls and laminations, occasional slickensides, slight to moderate porosity, gray to tan, slight to strong reaction with HCL. Core recovered in 0.1' to 2.9' lengths (most less than 1.0'). Most contacts are gradational.

Siltstone: carbonaceous and sandy in part, frequent shale partings, fresh to lightly weathered (Fe staining restricted to some joints), moderately hard, moderately well cemented, no distinct bedding, occasional joint inclined 30 degrees to 45 degrees to the horizontal, occasional slickensides, light to dark gray, frequent leaf imprints, slight to strong reaction with HCL. Core recovered in 0.1' to 1.0' lengths. Most breaks are approximately horizontal but rough and irregular. Most contacts are gradational.

Shale: carbonaceous and sandy in part, fresh to lightly weathered (Fe staining restricted to some breakage planes), slight to moderate air slaking, moderately cemented, fissility poorly to moderately developed. Occasional slickensides, gray to black, slight to no reaction with HCL. Core recovered in fragments to 0.3' lengths. Most contacts are gradational.

EXPLANATION

CORE LOSS / CORE RECOVERY

RB = rock bit
Fe = oxides of iron, i.e. limonite and hematite
HCL = hydrochloric acid (10% solution)

Type of hole . . . D = Diamond, H = Haystellite, S = Shot, C = Churn
Hole sealed . . . P = Packer, Cm = Cemented, Cs = Bottom of casing
Approx. size of hole (X-series) . . Ex = 1-1/2", Ax = 1-7/8", Bx = 2-3/8", Nx = 3"
Approx. size of core (X-series) . . Ex = 7/8", Ax = 1-1/8", Bx = 1-5/8", Nx = 2-1/8"
Outside dia. of casing (X-series) . Ex = 1-13/16", Ax = 2-1/4", Bx = 2-7/8", Nx = 3-1/2"
Inside dia. of casing (X-series) . . Ex = 1-1/2", Ax = 1-29/32", Bx = 2-3/8", Nx = 3"

FEATURE Collom Gulch Study Site PROJECT Emria STATE Colorado SHEET 1 OF 4 HOLE NO. DH-2

☆GPO 679-487

7-1337 (6-74)
Bureau of Reclamation

GEOLOGIC LOG OF DRILL HOLE

FEATURE Collom Gulch Study Site PROJECT Emria Coal Study STATE Colorado

HOLE NO. DH-2 LOCATION NE¼ SE¼, SEC 32, T.4 N., R. 94W. GROUND ELEV. 7335' ± DIP (ANGLE FROM HORIZ.) 90.0 degrees Down

COORDS. N. .... E. ....

BEGUN 09-13-80 FINISHED 09-22-80 DEPTH OF OVERBURDEN 6.0' TOTAL DEPTH 356.9' BEARING ....

DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED Not Measured LOGGED BY D. Grundvig LOG REVIEWED BY F. Thompson

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS	TYPE AND SIZE OF HOLE	CORE RECOVERY (%)	PERCOLATION TESTS: DEPTH (FEET) FROM (P, Cs, or Cm)	TO	LOSS (G.P.M.)	PRESSURE (P.S.I.)	LENGTH OF TEST (MIN.)	ELEVATION (FEET)	DEPTH (FEET)
								7235.0	100.0
	HQ wire-line	64			NONE	TAKEN			
								7228.6	106.4
								7227.5	107.5
	110	100							110
	(3½")							7220.7	114.3
								7218.8	116.2
								7215.3	119.7
	120	100							120
								7212.4	122.6
								7211.2	123.8
								7208.3	126.7
	130	100							130
								7200.7	134.3
	140	100							140
								7193.4	141.6
								7192.3	142.7
								7191.2	143.8
								7190.9	144.1
								7190.0	145.0
								7188.8	146.2
	150	100							150
								7183.9	151.1
								7181.4	153.6
								7179.8	155.2
								7178.0	157.0
	160	100							160
								7170.5	164.5
		100							
								7166.8	168.2
	170	100							170
								7164.3	170.7
								7157.9	177.1
								7155.6	179.4
	180 HQ wire-line	100							180
								7154.7	180.3
								7151.9	183.1
								7150.8	184.2
								7149.9	185.1
								7148.1	186.9
								7147.2	187.8
	190	100							190
		94						7135.0	200.0

GRAPHIC LOG

SAMPLES FOR TESTING

Driller: J. Dunn, B.O.R.

CLASSIFICATION AND PHYSICAL CONDITION

Coal: Dull to shiny black, mostly recovered in fragments less than 0.1'. Frequent thin carbonaceous shale partings.

6.0 - 29.9: Shale, considerable weathering in upper part.
29.9 - 30.9: Coal
30.9 - 31.5: Shale, black, carbonaceous
31.5 - 47.3: Sandstone, Intense Fe staining at 36.4.
47.3 - 52.6: Shale, occasional streak of coal.
52.6 - 74.8: Sandstone, tan.
74.8 - 75.5: Shale, carbonaceous.
75.5 - 86.8: Sandstone, small shale and siltstone lenses (less than 0.3' thick), carbonaceous in part.
86.8 - 87.3: Coal
87.3 - 99.0: Shale, frequent slickensides.
99.0 - 106.4: Sandstone, abrupt contact with coal below.
106.4 - 107.5: Coal
107.5 - 114.3: Shale, minor sandstone lenses to 0.3' thick.
114.3 - 116.2: Sandstone, minor shale partings.
116.2 - 119.7: Shale
119.7 - 122.6: Sandstone
122.6 - 123.8: Shale, 0.1' thick coal seam at 123.3.
123.8 - 126.7: Sandstone
126.7 - 134.3: Shale, occasional sandstone lenses.
134.3 - 141.6: Sandstone, minor shale lenses, carbonaceous in part.
141.6 - 142.7: Coal
142.7 - 143.8: Sandstone
143.8 - 144.1: Shale
144.1 - 145.0: Coal
145.0 - 146.2: Shale
146.2 - 151.1: Sandstone, shale parting at 147.4 and 148.3. Near vertical fracture 149.6 to 151.0.
151.1 - 153.6: Shale
153.6 - 155.2: Sandstone, carbonaceous in upper part.
155.2 - 157.0: Shale, air slakes badly.
157.0 - 164.5: Siltstone, carbonaceous, frequent leaf imprints.
164.5 - 168.2: Shale
168.2 - 170.7: Sandstone
170.7 - 177.1: Shale, with minor sandstone lenses.
177.1 - 179.4: Siltstone
179.4 - 180.3: Shale
180.3 - 183.1: Sandstone
183.1 - 184.2: Siltstone

EXPLANATION

CORE LOSS

CORE RECOVERY

Type of hole .... D = Diamond, H = Haystellite, S = Shot, C = Churn
Hole sealed .... P = Packer, Cm = Cemented, Cs = Bottom of casing
Approx. size of hole (X-series) .. Ex = 1-1/2", Ax = 1-7/8", Bx = 2-3/8", Nx = 3"
Approx. size of core (X-series) .. Ex = 7/8", Ax = 1-1/8", Bx = 1-5/8", Nx = 2-1/8"
Outside dia. of casing (X-series). Ex = 1-13/16", Ax = 2-1/4", Bx = 2-7/8", Nx = 3-1/2"
Inside dia. of casing (X-series) .. Ex = 1-1/2", Ax = 1-29/32", Bx = 2-3/8", Nx = 3"

☆GPO 679-482

7-1337 (6-74)
Bureau of Reclamation

GEOLOGIC LOG OF DRILL HOLE

SHEET 3 OF 4

FEATURE: Collom Gulch Study Site — PROJECT: Emria — STATE: Colorado

HOLE NO.: DH-2 — LOCATION: NE¼, SE¼, SEC. 32, T. 4, N., R. 94W. — GROUND ELEV.: 7335'± — DIP (ANGLE FROM HORIZ.): 90.0 degrees Down

COORDS. N. .... E. ....

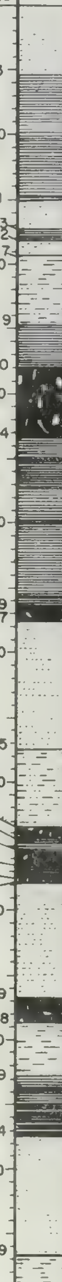
BEGUN: 09-13-80 — FINISHED: 09-22-80 — DEPTH OF OVERBURDEN: 6.0' — TOTAL DEPTH: 326.9' — BEARING: ....

DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED: Not Measured — LOGGED BY: D. Grundvig — LOG REVIEWED BY: F. Thompson

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS	TYPE AND SIZE OF HOLE	CORE RECOVERY (%)	PERCOLATION TESTS: DEPTH (FEET) FROM (P, Cs, or Cm)	TO	LOSS (G.P.M.)	PRESSURE (P.S.I.)	LENGTH OF TEST (MIN.)
	HQ wire-line (3½")	94, 6, 100, 100, 100, 100, 95, 100, 100, 100, 100, 100, 100			NONE	TAKEN	

ELEVATION (FEET)	DEPTH (FEET)
7135.0	200.0
7129.7	205.3
	210
7119.7	215.1
7117.7	217.3
7116.8	218.2
7115.3	219.7
	220
7110.1	224.9
7107.0	228.0
	230
7101.6	233.4
	240
7088.1	246.9
7087.3	247.7
	250
7077.5	257.5
	260
7071.6	263.4
7070.5	264.5
7069.9	265.1
7068.3	266.7
7066.5	268.5
7066.1	268.9
	270
7058.1	276.9
7056.2	278.8
	280
7052.1	282.9
7047.6	287.4
	290
7038.1	296.9
7035.0	300.0

GRAPHIC LOG



SAMPLES FOR TESTING

CLASSIFICATION AND PHYSICAL CONDITION

184.2 - 185.1: Shale, carbonaceous in part.
185.1 - 186.9: Coal, with carbonaceous shale.
186.9 - 187.8: Shale
187.8 - 205.3: Sandstone, salt and pepper appearance in part, several near-vertical joints (lightly Fe stained) and partially cemented near center of interval.
205.3 - 215.1: Shale? only 0.6' recovered, remainder of interval unknown
215.1 - 217.3: Sandstone
217.3 - 218.2: Shale
218.2 - 219.7: Sandstone
219.7 - 224.9: Siltstone
224.9 - 228.0: Shale
228.0 - 233.4: Coal
233.4 - 246.9: Shale
246.9 - 247.7: Coal
247.7 - 257.5: Sandstone
257.5 - 263.4: Siltstone
263.4 - 264.5: Coal, not submitted for testing.
264.5 - 265.1: Shale
265.1 - 266.7: Coal
266.7 - 268.5: Shale
268.5 - 268.9: Coal
268.9 - 276.9: Sandstone, minor shale partings.
276.9 - 278.8: Coal
278.8 - 282.9: Siltstone, with few sandstone lenses.
282.9 - 287.4: Shale
287.4 - 296.9: Sandstone
296.9 - 300.4: Siltstone
300.4 - 301.8: Coal
301.8 - 305.7: Shale, some slickensides.
305.7 - 311.5: Siltstone
311.5 - 321.8: Sandstone
321.8 - 326.9: Shale

EXPLANATION

CORE LOSS / CORE RECOVERY

Type of hole . . . . . D = Diamond, H = Haystellite, S = Shot, C = Churn
Hole sealed . . . . . P = Packer, Cm = Cemented, Cs = Bottom of casing
Approx. size of hole (X-series) . . Ex = 1-1/2", Ax = 1-7/8", Bx = 2-3/8", Nx = 3"
Approx. size of core (X-series) . . Ex = 7/8", Ax = 1-1/8", Bx = 1-5/8", Nx = 2-1/8"
Outside dia. of casing (X-series) . Ex = 1-13/16", Ax = 2-1/4", Bx = 2-7/8", Nx = 3-1/2"
Inside dia. of casing (X-series) . . Ex = 1-1/2", Ax = 1-29/32", Bx = 2-3/8", Nx = 3"

FEATURE: Collom Gulch Study Site — PROJECT: Emria — STATE: Colorado — SHEET 3 OF 4 — HOLE NO. DH-2

☆GPO 679-482

7-1337 (6-74)
Bureau of Reclamation

GEOLOGIC LOG OF DRILL HOLE

FEATURE Collom Gulch Study Site PROJECT Emria STATE Colorado

HOLE NO. DH-2 LOCATION NE¼, SE¼, SEC 32, T. 4 N., R. 94W. GROUND ELEV. 7335'± DIP (ANGLE FROM HORIZ.) 90.0 degrees Down

COORDS. N. E.

BEGUN 09-13-80 FINISHED 09-22-80 DEPTH OF OVERBURDEN 6.0' TOTAL DEPTH 326.9' BEARING

DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED Not Measured LOGGED BY D. Grundvig LOG REVIEWED BY F. Thompson

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS	TYPE AND SIZE OF HOLE	CORE RECOVERY (%)	PERCOLATION TESTS: DEPTH (FEET) FROM (P, Cs, or Cm)	TO	LOSS (G.P.M.)	PRESSURE (P.S.I.)	LENGTH OF TEST (MIN.)	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	SAMPLES FOR TESTING	CLASSIFICATION AND PHYSICAL CONDITION
								7035.0	300.0			
								7034.6	300.4			
		100			NONE	TAKEN		7033.2	301.8			
								7029.3	305.7			
	310	100						7023.5	311.5			
	320	100						7013.2	321.8			
								7008.1	326.9			
				TOTAL	DEPTH	326.9'						

EXPLANATION

CORE LOSS
CORE RECOVERY

Type of hole . . . D = Diamond, H = Haystellite, S = Shot, C = Churn
Hole sealed . . . P = Packer, Cm = Cemented, Cs = Bottom of casing
Approx. size of hole (X-series) . . Ex = 1-1/2", Ax = 1-7/8", Bx = 2-3/8", Nx = 3"
Approx. size of core (X-series) . . Ex = 7/8", Ax = 1-1/8", Bx = 1-5/8", Nx = 2-1/8"
Outside dia. of casing (X-series) . Ex = 1-13/16", Ax = 2-1/4", Bx = 2-7/8", Nx = 3-1/2"
Inside dia. of casing (X-series) . . Ex = 1-1/2", Ax = 1-29/32", Bx = 2-3/8", Nx = 3"

GPO 679-482

7-1337 (6-74)
Bureau of Reclamation

GEOLOGIC LOG OF DRILL HOLE

SHEET 1 OF 4

FEATURE Collom Gulch Study Site PROJECT Emria STATE Colorado

HOLE NO. DH-3 LOCATION NW¼ NE¼, SEC 34, T4N, R 94W, GROUND ELEV. 7290± 1/ DIP (ANGLE FROM HORIZ.) 90.0 degrees Down

COORDS. N. .... E. ....

BEGUN 09-23-80 FINISHED 09-27-80 DEPTH OF OVERBURDEN 2.0' TOTAL DEPTH 306.6' BEARING ....

DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED Not Measured LOGGED BY D. Grundvig LOG REVIEWED BY F. Thompson

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS	TYPE AND SIZE OF HOLE	CORE RECOVERY (%)	PERCOLATION TESTS: DEPTH (FEET) FROM (P, Cs, or Cm)	TO	LOSS (G.P.M.)	PRESSURE (P.S.I.)	LENGTH OF TEST (MIN.)	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	SAMPLES FOR TESTING	CLASSIFICATION AND PHYSICAL CONDITION

Percolation tests: NONE TAKEN

Driller: J. Dunn & K. Rasmussen, B.O.R.

NOTE: 1/
All measurements are from the ground surface. Hole was not surveyed, deviation (if any) from vertical is unknown.

PURPOSE OF HOLE:
To obtain samples for determination of overburden properties.

DRILLING EQUIPMENT:
Skid-mounted Sprague and Henwood

DRILLING FLUID:
Water, recirculated

DRILLING FLUID LOSSES:
Drillers reported no water return from 0.0' to 36.5', no losses from 36.5' to 76.6', 80% loss from 76.6' to 156.6', no losses from 156.6' to 206.6, and 25 to 50% losses for the remainder of the hole.

CASING RECORD:

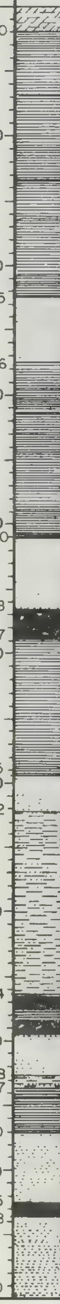
Cs Size of Cs (in.)	Depth (feet)	Hole Depth (feet)
-	-	20.0
4	19.0	20.0-306.6

HOLE COMPLETION:
Geophysical logs were run in hole by U.S.G.S.
Well points were installed with tips at 239.2' and 292.7' (10' influence zones) for ground water studies.
No unusual drilling conditions, other than loss of water, were reported by drillers.

Type and size of hole: RB (0-20); HQ Wireline ($3\frac{1}{2}$") (20-100)

Core recovery (%): 0; 100; 100; 96; 85; 100; 100; 100; 100; 100

Elevation (feet)	Depth (feet)
7290.0	0.0
7288.0	2.0
7267.5	22.5
7262.4	27.6
7249.0	41.0
7243.2	46.8
7241.3	48.7
7230.5	59.5
7227.8	62.2
7213.6	76.4
7211.4	78.6
7210.6	79.4
7207.2	82.8
7206.3	83.7
7203.0	87.0
7197.5	92.5
7196.2	93.8
7190.0	100.0



0.0 - 2.0: Lean Clay: Approximately 70% fines with medium plasticity, 30% fine sand, slight to moderate reaction with HCL, dark to light brown, dry.(CL)

2.0 - 306.6: Cretaceous Williams Fork Formation (Kw)
Interbedded sandstone, siltstone, shale, and coal. Individual units are described below.

Sandstone: principally quartzose but may be argillaceous and calcareous in part, very fine to medium, subangular to subrounded grains, fresh to moderately weathered, weakly to well cemented, bedding indistinct, lightly jointed, black carbonaceous swirls and laminations in part, occasional slickensides, slight to moderate porosity, light gray to yellow brown, strong to no reaction with HCL. Core recovered in fragments and lengths to 3.0' (most are less than 1.5'). Most contacts are gradational.

Siltstone: carbonaceous and sandy in part, frequent shale partings, fresh to moderately weathered, moderately hard, moderately well cemented, indistinct bedding, lightly jointed, occasional near-vertical fractures and slickensides, light to dark gray, frequent leaf imprints, slight to strong reaction with HCL. Core recovered in 0.1' to 0.7' lengths. Most breaks are inclined approximately 8-10 degrees to the horizontal with rough, irregular surface. Most contacts are gradational.

Shale: carbonaceous and sandy in part, fresh to moderately weathered, slight to moderate air slaking, fissility poorly to moderately developed. Occasional slickensides, gray to black, slight to no reaction with HCL. Core recovered in fragments to o.4' lengths. Most contacts are gradational.

EXPLANATION

CORE LOSS / CORE RECOVERY

RB = rock bit
Fe = oxides of iron, i.e. limonite, hematite
HCL = hydrochloric acid (10% solution)

Type of hole .... D = Diamond, H = Haystellite, S = Shot, C = Churn
Hole sealed .... P = Packer, Cm = Cemented, Cs = Bottom of casing
Approx. size of hole (X-series) . . Ex = 1-1/2", Ax = 1-7/8", Bx = 2-3/8", Nx = 3"
Approx. size of core (X-series) . . Ex = 7/8", Ax = 1-1/8", Bx = 1-5/8", Nx - 2-1/8"
Outside dia. of casing (X-series). Ex = 1-13/16", Ax = 2-1/4", Bx = 2-7/8", Nx = 3-1/2"
Inside dia. of casing (X-series). . Ex = 1-1/2", Ax = 1-29/32", Bx = 2-3/8", Nx = 3"

FEATURE Collom Gulch Study Site PROJECT Emria STATE Colorado SHEET 1 OF 4 HOLE NO. DH-3

☆GPO 679-482

7-1337 (6-74)
Bureau of Reclamation

GEOLOGIC LOG OF DRILL HOLE

SHEET 2 OF 4

FEATURE Collom Gulch Study Site PROJECT Emria STATE Colorado

HOLE NO DH-3 LOCATION NW¼, NE¼, SEC 34, T4N, R. 94W. GROUND ELEV. 7290+ DIP (ANGLE FROM HORIZ.) 90.0 degrees Down

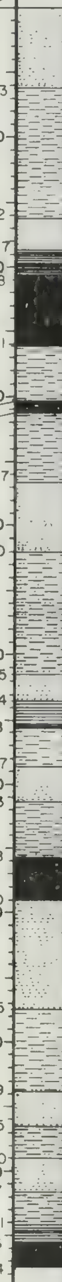
COORDS. N. .... E. ....

BEGUN 09-23-80 FINISHED 09-27-80 DEPTH OF OVERBURDEN 2.0' TOTAL DEPTH 306.6' BEARING ....

DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED Not Measured LOGGED BY D. Grundvig LOG REVIEWED BY F. Thompson

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS	TYPE AND SIZE OF HOLE	CORE RECOVERY (%)	PERCOLATION TESTS: DEPTH (FEET) FROM (P, Cs, or Cm)	TO	LOSS (G.P.M.)	PRESSURE (P.S.I.)	LENGTH OF TEST (MIN.)	ELEVATION (FEET)	DEPTH (FEET)
			NONE TAKEN					7190.0	100.0
		100						7183.7	106.3
	110	100							110
								7173.8	116.2
								7171.3	118.7
	120	100						7169.2	120 / 120.8
								7163.9	126.1
	130	100						7159.6	130 / 130.4
								7158.7	131.3
								7153.3	136.7
	140	100						7148.0	140 / 142.0
	150	100						7138.5	150 / 151.5
								7136.6	153.4
								7134.2	155.8
								7131.3	158.7
	160	100						7128.7	160 / 161.3
								7124.2	165.8
	170	100						7121.0	169.0 / 170
								7112.5	177.5
	180	100							180
								7106.1	183.9
								7103.5	186.5
	190	100						7101.0	189.0 / 190
								7098.3	191.7
								7095.9	194.1
								7094.4	195.6
		100						7092.6	197.4
								7090.0	200.0

GRAPHIC LOG



SAMPLES FOR TESTING

Driller: J. Dunn & K. Rasmussen
B.O.R.

CLASSIFICATION AND PHYSICAL CONDITION

Coal: dull to shiny black core recovered in fragments and lengths to 0.7'. Occasional shale parting.
2.0 - 22.5: Shale, intensely weathered, soft and crumbly.
22.5 - 27.6: Sandstone, Fe stained throughout.
27.6 - 41.0: Shale, occasional slickensides (70-85 degrees to the horizontal).
41.0 - 46.8: Sandstone
46.8 - 48.7: Coal
48.7 - 59.5: Shale
59.5 - 62.2: Sandstone, gray to white.
62.6 - 76.4: Siltstone, some coal streaks.
76.4 - 78.6: Shale
78.6 - 79.4: Coal
79.4 - 82.8: Sandstone
82.8 - 83.7: Siltstone
83.7 - 87.0: Shale, black.
87.0 - 92.5: Sandstone
92.5 - 93.8: Coal
93.8 - 106.3: Sandstone
106.3 - 116.2: Siltstone, carbonaceous in lower part.
116.2 - 118.7: Sandstone
118.7 - 120.8: Shale
120.8 - 126.1: Coal
126.1 - 130.4: Siltstone, shale parting at contact with coal.
130.4 - 131.3: Coal
131.3 - 136.7: Siltstone
136.7 - 142.0: Sandstone
142.0 - 151.5: Siltstone, with shale and sandstone lenses.
151.5 - 153.4: Sandstone
153.4 - 155.8: Shale, black.
155.8 - 158.7: Siltstone
158.7 - 161.3: Sandstone, salt and pepper appearance.
161.3 - 165.8: Siltstone
165.8 - 169.0: Coal
169.0 - 177.5: Sandstone
177.5 - 183.9: Siltstone, with shale lenses, dark gray to black.
183.9 - 186.5: Sandstone
186.5 - 189.0: Siltstone, with frequent shale partings.
189.0 - 191.7: Sandstone
191.7 - 194.1: Siltstone, several slickensides.
194.1 - 195.6: Shale
195.6 - 197.4: Coal
197.4 - 200.6: Sandstone
200.6 - 210.8: Siltstone, some black shale and coal streaks near bottom of interval.
210.8 - 231.4: Sandstone, slight Fe staining in part.

EXPLANATION

CORE LOSS
CORE RECOVERY

Type of hole . . . . . D = Diamond, H = Haystellite, S = Shot, C = Churn
Hole sealed . . . . . P = Packer, Cm = Cemented, Cs = Bottom of casing
Approx. size of hole (X-series) . . Ex = 1-1/2", Ax = 1-7/8", Bx = 2-3/8", Nx = 3"
Approx. size of core (X-series) . . Ex = 7/8", Ax = 1-1/8", Bx = 1-5/8", Nx = 2-1/8"
Outside dia. of casing (X-series). Ex = 1-13/16", Ax = 2-1/4", Bx = 2-7/8", Nx = 3-1/2"
Inside dia. of casing (X-series) . . Ex = 1-1/2", Ax = 1-29/32", Bx = 2-3/8", Nx = 3"

FEATURE Collom Gulch Study Site PROJECT Emria STATE Colorado SHEET 2 OF 4 HOLE NO. DH-3

☆ GPO 679 482

7-1337 (6-74)
Bureau of Reclamation

GEOLOGIC LOG OF DRILL HOLE

SHEET 3 OF 4

FEATURE Collom Gulch Study Site PROJECT Emria STATE Colorado

HOLE NO. DH-3 LOCATION NW¼ NE¼, SEC 34, T4N R. 94W. GROUND ELEV. 7290± DIP (ANGLE FROM HORIZ.) 90.0 degrees Down

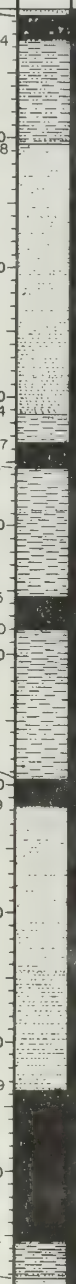
COORDS. N. E.

BEGUN 09-23-80 FINISHED 09-27-80 DEPTH OF OVERBURDEN 2.0' TOTAL DEPTH 306.6' BEARING

DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED Not Measured LOGGED BY D. Grundvig LOG REVIEWED BY F. Thompson

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS	TYPE AND SIZE OF HOLE	CORE RECOVERY (%)	PERCOLATION TESTS: DEPTH (FEET) FROM (P, Cs, or Cm)	TO	LOSS (G.P.M.)	PRESSURE (P.S.I.)	LENGTH OF TEST (MIN.)	ELEVATION (FEET)	DEPTH (FEET)
				NONE TAKEN				7090.0	200.0
		100						7089.4	200.6
		100						7087.6	202.4
	210	100						7079.2	210.8
	220	100							220
	230	100						7058.6	231.4
								7056.3	233.7
								7054.4	235.6
	240	100							240
								7044.5	245.5
								7042.0	248.0
	250	100							250
								7030.3	259.7
	260	100						7028.1	261.9
	270	100							270
	280	100							280
								7006.1	283.9
	290	100							290
								6994.6	295.4
		100						6991.7	298.3
								6990.0	300.0

GRAPHIC LOG



SAMPLES FOR TESTING

CLASSIFICATION AND PHYSICAL CONDITION

231.4 - 233.7: Siltstone, carbonaceous
233.7 - 235.6: Coal
235.6 - 245.5: Siltstone, black and carbonaceous in part.
245.5 - 248.0: Coal
248.0 - 259.7: Siltstone, with frequent shale lenses, light air slaking.
259.7 - 261.9: Coal
261.9 - 283.9: Sandstone, with frequent siltstone lenses to 0.3' thick.
283.9 - 295.4: Coal
295.4 - 298.3: Siltstone
298.3 - 306.6: Sandstone, laminated in upper part only.

EXPLANATION

CORE LOSS
CORE RECOVERY

Type of hole . . . . D = Diamond, H = Haystellite, S = Shot, C = Churn
Hole sealed . . . . P = Packer, Cm = Cemented, Cs = Bottom of casing
Approx. size of hole (X-series) . . Ex = 1-1/2", Ax = 1-7/8", Bx = 2-3/8", Nx = 3"
Approx. size of core (X-series) . . Ex = 7/8", Ax = 1-1/8", Bx = 1-5/8", Nx = 2-1/8"
Outside dia. of casing (X-series) . Ex = 1-13/16", Ax = 2-1/4", Bx = 2-7/8", Nx = 3-1/2"
Inside dia. of casing (X-series) . . Ex = 1-1/2", Ax = 1-29/32", Bx = 2-3/8", Nx = 3"

7-1337 (6-74)
Bureau of Reclamation

GEOLOGIC LOG OF DRILL HOLE

SHEET 4 OF 4

FEATURE Collom Gulch Study Site PROJECT Emria STATE Colorado

HOLE NO DH-3 LOCATION NW¼ NE¼, SEC 34, T4N R. 94W. GROUND ELEV. 7290± DIP (ANGLE FROM HORIZ.) 90.0 degrees Down

COORDS. N. E.

BEGUN 09-23-80 FINISHED 09-27-80 DEPTH OF OVERBURDEN 2.0' TOTAL DEPTH 306.6' BEARING

DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED Not Measured LOGGED BY D. Grundvig LOG REVIEWED BY E. Thompson

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS	TYPE AND SIZE OF HOLE	CORE RECOVERY (%)	PERCOLATION TESTS: DEPTH (FEET) FROM (P, Cs, or Cm)	TO	LOSS (G.P.M.)	PRESSURE (P.S.I.)	LENGTH OF TEST (MIN.)	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	SAMPLES FOR TESTING	CLASSIFICATION AND PHYSICAL CONDITION
								6990.0	300.0			
	HQ Wire-line			NONE	TAKEN							
								6983.4	306.6			
				TOTAL	DEPTH	306.6'						

EXPLANATION

CORE LOSS

CORE RECOVERY

Type of hole . . . . D = Diamond, H = Haystellite, S = Shot, C = Churn
Hole sealed . . . . P = Packer, Cm = Cemented, Cs = Bottom of casing
Approx. size of hole (X-series) . . Ex = 1-1/2", Ax = 1-7/8", Bx = 2-3/8", Nx = 3"
Approx. size of core (X-series) . . Ex = 7/8", Ax = 1-1/8", Bx = 1-5/8", Nx – 2-1/8"
Outside dia. of casing (X-series). Ex = 1-13/16", Ax = 2-1/4", Bx = 2-7/8", Nx = 3-1/2"
Inside dia. of casing (X-series). . Ex = 1-1/2", Ax = 1-29/32", Bx = 2-3/8", Nx = 3"

☆GPO 679-482

7-1337 (6-74)
Bureau of Reclamation

GEOLOGIC LOG OF DRILL HOLE

SHEET 1 OF 3

FEATURE Collom Gulch Study Site PROJECT Emria Coal Study STATE Colorado

HOLE NO. DH-4 LOCATION NW¼ NW¼, SEC 3, T. 4 N., R. 94W. GROUND ELEV. 7570± 1/ DIP (ANGLE FROM HORIZ.) 90.0 degrees Down

COORDS. N. .... E. ....

BEGUN 10-02-80 FINISHED 10-17-80 DEPTH OF OVERBURDEN 4.0' TOTAL DEPTH 206.6' BEARING ....

DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED Not Measured LOGGED BY D. Grundvig LOG REVIEWED BY F. Thompson

Driller: J. Dunn & K. Rasmussen B.O.R.

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS

NOTE: 1/
All measurements are from ground surface. Hole was not surveyed, deviation (if any) from vertical is unknown.

PURPOSE OF HOLE:
To obtain samples for determination of overburden properties.

DRILLING EQUIPMENT:
Skid-mounted Sprague and Henwood

DRILLING FLUID:
Water, recirculated

DRILLING FLUID LOSSES:
Driller reports 100% loss from 15.0 to the bottom of the hole (206.6').

CASING RECORD:

Cs Size (in.)	Depth of Cs (feet)	Depth of Hole (feet)
-	-	0.0-15.0
4	15.0	15.0-206.6

HOLE COMPLETION:
Driller twisted off core barrel and wire line in hole unable to retrieve. Hole was backfilled and abandoned.

TYPE AND SIZE OF HOLE: 0–15: 4½" RB; 15–100: HQ Wire-line (3½")

CORE RECOVERY (%): 0, 44, 51, 100, 100, 100, 100, 100, 100

PERCOLATION TESTS: NONE TAKEN

ELEVATION (FEET)	DEPTH (FEET)
7570.0	0.0
7566.0	4.0
7564.0	6.0
7555.5	14.5
7527.6	42.4
7524.3	45.7
7522.2	47.8
7520.7	49.3
7498.8	71.2
7496.5	73.5
7493.4	76.6
7488.7	81.3
7480.7	89.3
7478.0	92.0
7475.8	94.2
7472.0	98.0
7470.0	100.0

CLASSIFICATION AND PHYSICAL CONDITION

0.0 - 4.0: Lean Clay: Approximately 70% fines with medium plasticity, 30% fine sand, slight to moderate reaction with HCL, dark to light brown, dry.(CL)

4.0 - 206.6: Cretaceous Williams Fork Formation (Kw)
Interbedded sandstone, siltstone, shale, and coal. Individual units are described below.

Sandstone: principally quartzose but may be argillaceous in part, very fine to medium grained, subangular to subrounded grains, fresh to moderately weathered (mostly fresh), weakly to well cemented (most is moderately cemented), bedding indistinct, lightly jointed, frequent black laminations and swirls, occasional slickensides, slight to moderate porosity, gray to tan, slight to strong reaction with HCL. Core recovered in 0.1' to 2.0' lengths (most less than 1.0'). Most contacts are gradational.

Siltstone: carbonaceous and sandy in part, frequent shale partings, fresh to lightly weathered (Fe staining restricted to some joints), moderately hard, moderately well cemented, bedding indistinct, occasional joint inclined 30 degrees to 75 degrees to the horizontal, occasional slickensides, light to dark gray, slight to strong reaction with HCL. Core recovered in 0.1' to 1.5' lengths. Most breaks are approximately horizontal but rough and irregular. Most contacts are gradational.

Shale: carbonaceous and sandy in part, fresh to lightly weathered (Fe staining restricted to some breakage planes), slight to moderate air slaking, moderately cemented, fissility poorly to moderately developed. Gray to black, slight to no reaction to HCL. Core recovered in fragments to 0.3' lengths. Most contacts are gradational.

EXPLANATION

CORE LOSS / CORE RECOVERY

RB = rock bit
FE = oxides of iron, i.e. limonite and hematite
HCL = hydrochloric acid (10% solution)

Type of hole .... D = Diamond, H = Haystellite, S = Shot, C = Churn
Hole sealed .... P = Packer, Cm = Cemented, Cs = Bottom of casing
Approx. size of hole (X-series) .. Ex = 1-1/2", Ax = 1-7/8", Bx = 2-3/8", Nx = 3"
Approx. size of core (X-series) .. Ex = 7/8", Ax = 1-1/8", Bx = 1-5/8", Nx = 2-1/8"
Outside dia. of casing (X-series). Ex = 1-13/16", Ax = 2-1/4", Bx = 2-7/8", Nx = 3-1/2"
Inside dia. of casing (X-series) .. Ex = 1-1/2", Ax = 1-29/32", Bx = 2-3/8", Nx = 3"

FEATURE Collom Gulch Study Site PROJECT Emria STATE Colorado SHEET 1 OF 3 HOLE NO. DH-4

☆ GPO 679-482

7-1337 (6-74)
Bureau of Reclamation

GEOLOGIC LOG OF DRILL HOLE

FEATURE Collom Gulch Study Site PROJECT Emria Coal Study STATE Colorado

HOLE NO. DH-4 LOCATION NW¼ NW¼, SEC 3, T.4 N., R. 94W. GROUND ELEV. 7570± DIP (ANGLE FROM HORIZ.) 90.0 degrees Down

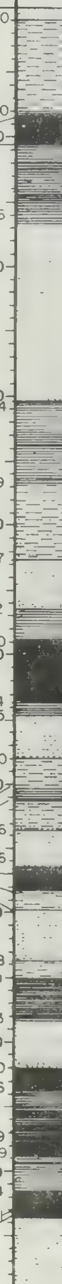
COORDS. N. E.

BEGUN 10-02-80 FINISHED 10-17-80 DEPTH OF OVERBURDEN 4.0' TOTAL DEPTH 206.6' BEARING

DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED Not Measured LOGGED BY D. Grundvig LOG REVIEWED BY F. Thompson

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS	TYPE AND SIZE OF HOLE	CORE RECOVERY (%)	PERCOLATION TESTS: DEPTH (FEET) FROM (P, Cs, or Cm)	TO	LOSS (G.P.M.)	PRESSURE (P.S.I.)	LENGTH OF TEST (MIN.)	ELEVATION (FEET)	DEPTH (FEET)
	HQ Wire-line ($3\frac{1}{2}$")	100	NONE TAKEN					7470.0	100.0
	110	100						7469.0	101.0
	120	100						7462.0	108.0
	130	100						7461.5	108.5
	140	100						7459.3	110.7
	150	100						7453.4	116.6
	160	100						7439.6	130.4
	170	100						7433.1	136.9
	180 HQ Wire-line ($3\frac{1}{2}$")	100						7427.3	142.7
	190	100						7423.8	146.2
		100						7421.0	149.0
								7416.6	153.4
								7415.5	154.5
								7412.0	158.0
								7409.7	160.3
								7409.0	161.0
								7406.4	163.6
								7403.4	166.6
								7403.0	167.0
								7401.9	168.1
								7400.1	169.9
								7396.2	173.8
								7395.0	175.0
								7391.7	178.3
								7388.0	182.0
								7386.4	183.6
								7382.1	187.9
								7381.1	188.9
								7388.6	191.4
								7376.9	193.1
								7376.6	193.4
								7370.0	200.0

GRAPHIC LOG



SAMPLES FOR TESTING

CLASSIFICATION AND PHYSICAL CONDITION

Coal: Dull to shiny black, mostly recovered in lengths less than 0.3'. Frequent thin carbonaceous shale partings.

4.0 - 6.0: Siltstone
6.0 - 14.5: Shale
14.5 - 42.4: Sandstone, friable on edges, some core body Fe stained. Numerous horizontal breaks (suspect mechanical breakage).
42.4 - 45.7: Shale; black, carbonaceous
45.7 - 47.8: Coal
47.8 - 49.3: Shale; black, carbonaceous
49.3 - 71.2: Sandstone; shale lense at 62.4' (0.8' thick).
71.2 - 73.5: Shale; black, carbonaceous
73.5 - 76.6: Coal
76.6 - 81.3: Shale; black, carbonaceous
81.3 - 92.0: Shale; 0.3' thick coal seam at 91.1.
92.0 - 94.2: Sandstone
94.2 - 98.0: Shale; black, carbonaceous
98.0 - 101.1: Sandstone
101.1 - 108.0: Siltstone; 1.2' thick sandstone lense at 106.1.
108.0 - 108.5: Shale
108.5 - 110.7: Coal
110.7 - 116.6: Shale
116.6 - 130.4: Sandstone; 0.6' thick seam of coal and carbonaceous shale at 122.4.
130.4 - 136.9: Shale: frequent slickensides (all orientations).
136.9 - 142.7: Siltstone
142.7 - 146.2: Sandstone; some slickensides oriented 5 degrees to 10 degrees to the horizontal.
146.2 - 149.0: Shale: numerous slickensides.
149.0 - 153.4: Coal
153.4 - 154.5: Shale; black, carbonaceous.
154.5 - 158.0: Sandstone
158.0 - 160.3: Siltstone
160.3 - 161.0: Shale
161.0 - 163.6: Siltstone
163.6 - 166.6: Sandstone
166.6 - 167.0: Shale; black, carbonaceous.
167.0 - 168.1: Coal
168.1 - 169.9: Siltstone
169.9 - 173.8: Sandstone
173.8 - 175.0: Siltstone
175.0 - 178.3: Shale; black, carbonaceous.
178.3 - 182.0: Sandstone
182.0 - 183.6: Coal

EXPLANATION

CORE LOSS
CORE RECOVERY

Type of hole . . . . . D = Diamond, H = Haystellite, S = Shot, C = Churn
Hole sealed . . . . . P = Packer, Cm = Cemented, Cs = Bottom of casing
Approx. size of hole (X-series) . . Ex = 1-1/2", Ax = 1-7/8", Bx = 2-3/8", Nx = 3"
Approx. size of core (X-series) . . Ex = 7/8", Ax = 1-1/8", Bx = 1-5/8", Nx = 2-1/8"
Outside dia. of casing (X-series) . Ex = 1-13/16", Ax = 2-1/4", Bx = 2-7/8", Nx = 3-1/2"
Inside dia. of casing (X-series) . . Ex = 1-1/2", Ax = 1-29/32", Bx = 2-3/8", Nx = 3"

7-1337 (6-74)
Bureau of Reclamation

GEOLOGIC LOG OF DRILL HOLE

SHEET 3 OF 3

FEATURE Collom Gulch Study Site PROJECT Emria Coal Study STATE Colorado

HOLE NO DH-4 LOCATION NW¼ NW¼, SEC 3, T. 4 N., R. 94W. GROUND ELEV. 7570± DIP (ANGLE FROM HORIZ.) 90.0 degrees Down

COORDS. N. E.

BEGUN 10-02-80 FINISHED 10-17-80 DEPTH OF OVERBURDEN 4.0' TOTAL DEPTH 206.6' BEARING

DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED Not Measured LOGGED BY D. Grundvig LOG REVIEWED BY F. Thompson

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS	TYPE AND SIZE OF HOLE	CORE RECOVERY (%)	PERCOLATION TESTS DEPTH (FEET) FROM (P, Cs, or Cm)	TO	LOSS (G.P.M.)	PRESSURE (P.S.I.)	LENGTH OF TEST (MIN.)	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	SAMPLES FOR TESTING	CLASSIFICATION AND PHYSICAL CONDITION
								7370.0	200.0			
	HQ Wire-line ($3\frac{1}{2}$")	100										183.6 - 187.9: Shale; minor amounts pyrite in lower part. 187.9 - 188.9: Coal 188.9 - 191.4: Shale 191.4 - 193.1: Coal 193.1 - 193.4: Shale 193.4 - 206.6: Sandstone
								7363.4	206.6			
				TOTAL	DEPTH	206.6'						

EXPLANATION

CORE LOSS

CORE RECOVERY

Type of hole . . . . D = Diamond, H = Haystellite, S = Shot, C = Churn
Hole sealed . . . . P = Packer, Cm = Cemented, Cs = Bottom of casing
Approx. size of hole (X-series) . . Ex = 1-1/2", Ax = 1-7/8", Bx = 2-3/8", Nx = 3"
Approx. size of core (X-series) . . Ex = 7/8", Ax = 1-1/8", Bx = 1-5/8", Nx = 2-1/8"
Outside dia. of casing (X-series) . Ex = 1-13/16", Ax = 2-1/4", Bx = 2-7/8", Nx = 3-1/2"
Inside dia. of casing (X-series) . . Ex = 1-1/2", Ax = 1-29/32", Bx = 2-3/8", Nx = 3"

FEATURE Collom Gulch Study Site PROJECT Emria STATE Colorado SHEET 3 OF 3 HOLE NO. DH-4

☆GPO 679-482

7-1337 (6-74)
Bureau of Reclamation

GEOLOGIC LOG OF DRILL HOLE

SHEET 1 OF 4

FEATURE Collom Gulch Study Site PROJECT Emria Coal Study STATE Colorado

HOLE NO. DH-5 LOCATION SW¼ NE¼, SEC 6, T 3 N, R94W, GROUND ELEV. 7960.0± 1/ DIP (ANGLE FROM HORIZ.) 90.0 degrees Down

COORDS. N. .... E. ....

BEGUN 09-28-80 FINISHED 10-02-81 DEPTH OF OVERBURDEN 2.0' TOTAL DEPTH 306.6' BEARING ---

DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED Not Measured LOGGED BY D. Grundvig LOG REVIEWED BY F. Thompson

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS	TYPE AND SIZE OF HOLE	CORE RECOVERY (%)	PERCOLATION TESTS	ELEVATION (FEET)	DEPTH (FEET)
				7960.0	0.0
NOTE: 1/ All measurements are from ground surface. Hole was not surveyed, deviation (if any) from vertical is unknown.	RB	0	NONE TAKEN		2.0
PURPOSE OF HOLE: To obtain samples for determination of overburden properties.	HQ Wire-line (3½")	100			
		100		7937.9	22.1
DRILLING EQUIPMENT: Skid-mounted Sprague and Henwood		95		7924.4	35.6
DRILLING FLUID: Water, recirculated				7922.8	37.2
DRILLING FLUID LOSSES: Driller reports 80-100% water losses 0.0 to 306.6		100		7920.6	39.4
		45		7903.5	56.5
		100		7899.7	60.3
				7898.2	61.8
				7897.5	62.5
				7896.6	63.4
				7892.2	67.8
		100		7888.5	71.5
				7886.4	73.6
		100		7873.3	86.7
				7871.6	88.4
				7870.1	89.9
	HQ Wire line (3½")	100		7867.4	92.6
		100		7863.2	96.8
				7860.0	100.0

CASING RECORD:

Cs Size (in.)	Depth of Cs (ft.)	Depth of Hole (ft.)
-	-	0.0 - 20.0
4	20.0	20.0-306.6

HOLE COMPLETION: Geophysical logs were run in hole by U.S.G.S. Well points were installed with tips at 170.0 and 217.7. Length of influence zones not reported by driller. No unusual drilling conditions reported other than no water circulation.

GRAPHIC LOG

CLASSIFICATION AND PHYSICAL CONDITION

0.0 - 2.0: Lean Clay: Approximately 70% fines with medium plasticity, 30% fine sand, slight to moderate reaction with HCL, dark to light brown, dry. (CL).

2.0 - 306.6: Cretaceous Williams Fork Formation (Kw)
Interbedded sandstone, siltstone, shale, and coal. Individual units are described below.

Sandstone: principally quartzose but may be argillaceous and calcareous in part, very fine to medium grained, subangular to subrounded grains, fresh to moderately weathered, weakly to well cemented, bedding indistinct, lightly jointed, black carbonaceous swirls and laminations in part, occasional slickensides, slight to moderate porosity, light gray to yellow brown, strong to no reaction with HCL. Core recovered in fragments to 2.4' lengths (most less than 1.5). Most contacts are gradational.

Siltstone: carbonaceous and sandy in part, frequent shale partings, fresh to moderately weathered, moderately hard, moderately well cemented, indistinct bedding, lightly jointed, occasional near-vertical fractures and slickensides, frequent leaf imprints, slight to strong reaction with HCL. Core recovered in 0.1' to 0.7' lengths. Most breaks are inclined approximately 8-10 degrees to the horizontal with rough, irregular surfaces. Most contacts are gradational.

Shale: carbonaceous and sandy in part, fresh to moderately weathered, slight to moderate air slaking, fissility poorly to moderately developed. Occasional slickensides, gray to black, slight to no reaction with HCL. Core recovered in fragments to 0.4' lengths. Most contacts are gradational.

EXPLANATION

CORE LOSS / CORE RECOVERY

RB = rock bit
FE = oxides of iron, i.e. limonite and hematite
HCL = hydrochloric acid (10% solution)

Type of hole .... D = Diamond, H = Haystellite, S = Shot, C = Churn
Hole sealed .... P = Packer, Cm = Cemented, Cs = Bottom of casing
Approx. size of hole (X-series) .. Ex = 1-1/2", Ax = 1-7/8", Bx = 2-3/8", Nx = 3"
Approx. size of core (X-series) .. Ex = 7/8", Ax = 1-1/8", Bx = 1-5/8", Nx = 2-1/8"
Outside dia. of casing (X-series). Ex = 1-13/16", Ax = 2-1/4", Bx = 2-7/8", Nx = 3-1/2"
Inside dia. of casing (X-series) .. Ex = 1-1/2", Ax = 1-29/32", Bx = 2-3/8", Nx = 3"

FEATURE Collom Gulch Study Site PROJECT Emria STATE Colorado SHEET 1 OF 4 HOLE NO. DH-5

☆GPO 679-482

7-1337 (6-74)
Bureau of Reclamation

GEOLOGIC LOG OF DRILL HOLE

SHEET 2 OF 4

FEATURE Collom Gulch Study Site PROJECT Emria Coal Study STATE Colorado

HOLE NO. DH-5 LOCATION SW¼ NE¼ SEC 6 T.3.N. R94W. GROUND ELEV. 7960± 1/ DIP (ANGLE FROM HORIZ.) 90.0 degrees Down

COORDS. N. E.

BEGUN 09-28-80 FINISHED 10-02-81 DEPTH OF OVERBURDEN 2.0' TOTAL DEPTH 306.6' BEARING

DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED Not Measured LOGGED BY D. Grundvig LOG REVIEWED BY F. Thompson

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS	TYPE AND SIZE OF HOLE	CORE RECOVERY (%)	PERCOLATION TESTS: DEPTH (FEET) FROM (P, Cs, or Cm)	TO	LOSS (G.P.M.)	PRESSURE (P.S.I.)	LENGTH OF TEST (MIN.)	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	SAMPLES FOR TESTING
								7860.0	100.0		
	HQ Wire-line (3½")	100						7857.5	102.5		
								7855.4	104.6		
								7852.5	107.5		
								7850.4	109.6		
	110	100							110		
								7844.9	115.1		
								7842.9	117.1		
	120	100							120		
								7836.4	123.6		
	130	100							130		
	140	100							140		
								7812.8	147.2		
	150	100							150		
								7808.4	151.6		
								7806.7	153.3		
								7803.2	156.8		
								7802.3	157.7		
	160	100							160		
								7798.5	161.5		
	170	100							170		
								7787.9	172.1		
								7786.8	173.2		
								7784.8	175.2		
								7782.5	177.5		
	180	100							180		
	190 HQ Wire line (3½")	100							190		
								7765.9	194.1		
								7764.4	195.6		
		100						7760.3	199.7		
								7760.0	200.0		

CLASSIFICATION AND PHYSICAL CONDITION

Coal: dull to shiny black, mostly recovered in fragments to 0.6' lengths. Frequent, thin carbonaceous shale partings.

2.0 - 22.1: Shale, mod. Fe staining
22.1 - 35.6: Sandstone, intense Fe staining
35.6 - 37.2: Shale
37.2 - 39.4: Coal
39.4 - 56.5: Shale; black, carbonaceous
56.5 - 60.3: Sandstone, gray.
60.3 - 61.8: Shale
61.8 - 62.5: Sandstone, gray.
62.5 - 63.4: Siltstone
63.4 - 67.8: Sandstone, gray.
67.8 - 71.5: Shale, black, carbonaceous
71.5 - 73.6: Siltstone, minor coal seam at 73.3.
73.6 - 86.7: Sandstone, slickensides inclined 45 degrees at 75.5', high-angle breaks for next foot (partially healed-intense Fe staining).
86.7 - 88.4: Shale with coal laminations.
88.4 - 89.9: Sandstone, gray
89.9 - 92.6: Shale
92.6 - 96.8: Sandstone
96.8 - 102.5: Shale
102.5 - 104.6: Coal
104.6 - 107.5: Siltstone
107.5 - 109.6: Sandstone, 4 breaks inclined approximately 10 degrees to the horizontal.
109.6 - 115.1: Coal
115.1 - 117.1: Sandstone
117.1 - 123.6: Siltstone, with minor shale lenses throughout.
123.6 - 147.2: Sandstone, numerous siltstone lenses, slickensides at 144.0 (inclined 35 degrees to the horizontal).
147.2 - 151.6: Coal
151.6 - 153.3: Shale
153.3 - 156.8: Sandstone
156.8 - 157.7: Shale
157.7 - 161.5: Coal
161.5 - 172.1: Sandstone with minor shale partings.
172.1 - 173.2: Siltstone
173.2 - 175.2: Coal
175.2 - 177.5: Shale; black, carbonaceous.
177.5 - 194.1: Sandstone, dark gray to white, salt and pepper appearance near middle of interval. Lengths to 2.4'.
194.1 - 195.6: Siltstone
195.6 - 199.7: Coal
199.7 - 208.1: Shale with occasional coal streaks.
208.1 - 224.6: Sandstone

EXPLANATION

CORE LOSS
CORE RECOVERY

Type of hole . . . D = Diamond, H = Haystellite, S = Shot, C = Churn
Hole sealed . . . P = Packer, Cm = Cemented, Cs = Bottom of casing
Approx. size of hole (X-series) . . Ex = 1-1/2", Ax = 1-7/8", Bx = 2-3/8", Nx = 3"
Approx. size of core (X-series) . . Ex = 7/8", Ax = 1-1/8", Bx = 1-5/8", Nx = 2-1/8"
Outside dia. of casing (X-series) . Ex = 1-13/16", Ax = 2-1/4", Bx = 2-7/8", Nx = 3-1/2"
Inside dia. of casing (X-series) . . Ex = 1-1/2", Ax = 1-29/32", Bx = 2-3/8", Nx = 3"

FEATURE Collom Gulch Study Site PROJECT Emria STATE Colorado SHEET 2 OF 4 HOLE NO. DH-5

☆ GPO 679-482

7-1337 (6-74)
Bureau of Reclamation

GEOLOGIC LOG OF DRILL HOLE

SHEET 3 OF 4

FEATURE Collom Gulch Study Site PROJECT Emria Coal Study STATE Colorado
HOLE NO DH-5 LOCATION SW¼ NE¼ SEC6 T.3 N. R.94W. GROUND ELEV. 7960± 1/ DIP (ANGLE FROM HORIZ) 90.0 degrees Down
COORDS. N. E.
BEGUN 09-28-80 FINISHED 10-02-81 DEPTH OF OVERBURDEN 2.0' TOTAL DEPTH 306.6' BEARING
DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED Not Measured LOGGED BY D. Grundvig LOG REVIEWED BY F. Thompson

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS	TYPE AND SIZE OF HOLE	CORE RECOVERY (%)	PERCOLATION TESTS: DEPTH (FEET) FROM (P, Cs, or Cm)	TO	LOSS (G.P.M.)	PRESSURE (P.S.I.)	LENGTH OF TEST (MIN.)	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	SAMPLES FOR TESTING	CLASSIFICATION AND PHYSICAL CONDITION
								7760.0	200.0			
	HQ Wire-line (3½")	100										224.6 - 228.7: Siltstone
												228.7 - 232.0: Coal
												232.0 - 233.5: Siltstone
												233.5 - 237.6: Sandstone
								7751.9	208.1			237.6 - 238.4: Siltstone
	210	100							210			238.4 - 249.1: Coal
												249.1 - 258.2: Siltstone
												258.2 - 285.7: Sandstone
												285.7 - 291.9: Coal
												291.9 - 296.4: Sandstone
	220	100							220			296.4 - 303.1: Siltstone
												303.1 - 306.6: Sandstone
								7735.4	224.6			
								7731.3	228.7			
	230	100							230			
								7728.0	232.0			
								7726.5	233.5			
								7722.4	237.6			
								7721.6	238.4			
	240	100							240			
								7710.9	249.1			
	250	100							250			
								7701.8	258.2			
	260	100							260			
	270	100							270			
	280	100							280			
								7674.3	285.7			
	290	100							290			
	HQ Wire-line (3½")							7668.1	291.9			
								7663.6	296.4			
		100						7660.0	300.0			

EXPLANATION

CORE LOSS
CORE RECOVERY

Type of hole . . . . . . D = Diamond, H = Haystellite, S = Shot, C = Churn
Hole sealed . . . . . . P = Packer, Cm = Cemented, Cs = Bottom of casing
Approx. size of hole (X-series) . . Ex = 1-1/2", Ax = 1-7/8", Bx = 2-3/8", Nx = 3"
Approx. size of core (X-series) . . Ex = 7/8", Ax = 1-1/8", Bx = 1-5/8", Nx – 2-1/8"
Outside dia. of casing (X-series). Ex = 1-13/16", Ax = 2-1/4", Bx = 2-7/8", Nx = 3-1/2"
Inside dia. of casing (X-series). . Ex = 1-1/2", Ax = 1-29/32", Bx = 2-3/8", Nx = 3"

FEATURE Collom Gulch Study Site PROJECT Emria STATE Colorado SHEET 3 OF 4 HOLE NO. DH-5

☆GPO 679-482

GEOLOGIC LOG OF DRILL HOLE

FEATURE Collom Gulch Study Site PROJECT Emria Coal Study STATE Colorado

HOLE NO. DH-5 LOCATION SW¼ NE¼ SEC 6 T.3 N. R94W. GROUND ELEV. 7960± 1/ DIP (ANGLE FROM HORIZ.) 90.0 degrees Down

COORDS. N. E.

BEGUN 09-28-80 FINISHED 10-02-81 DEPTH OF OVERBURDEN 2.0' TOTAL DEPTH 306.6' BEARING

DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED Not Measured LOGGED BY D. Grundvig LOG REVIEWED BY F. Thompson

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS	TYPE AND SIZE OF HOLE	CORE RECOVERY (%)	PERCOLATION TESTS DEPTH (FEET) FROM (P, Cs, or Cm)	TO	LOSS (G.P.M.)	PRESSURE (P.S.I.)	LENGTH OF TEST (MIN.)	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	SAMPLES FOR TESTING	CLASSIFICATION AND PHYSICAL CONDITION
								7660.0	300.0			
	HQ Wire-line (3½")	100		NONE	TAKEN			7656.9	303.1			
								7653.4	306.6			
				TOTAL	DEPTH	306.6'						

EXPLANATION

CORE LOSS
CORE RECOVERY

Type of hole . . . D = Diamond, H = Haystellite, S = Shot, C = Churn
Hole sealed . . . P = Packer, Cm = Cemented, Cs = Bottom of casing
Approx. size of hole (X-series) . . Ex = 1-1/2", Ax = 1-7/8", Bx = 2-3/8", Nx = 3"
Approx. size of core (X-series) . . Ex = 7/8", Ax = 1-1/8", Bx = 1-5/8", Nx – 2-1/8"
Outside dia. of casing (X-series). Ex = 1-13/16", Ax = 2-1/4", Bx = 2-7/8", Nx = 3-1/2"
Inside dia. of casing (X-series). . Ex = 1-1/2", Ax = 1-29/32", Bx = 2-3/8", Nx = 3"

APPENDIX B

COAL ANALYSIS
COLLOM GULCH SITE

Prepared by
Geochemical Testing
Coal, Water, and Materials Analysis
R.D. 2, Box 124
Somerset, PA 15501

Director of Technical Services
Forrest E. Walker

Contracted by
United States Geological Survey

Report dated
May 25, 1982

APPENDIX B

COAL ANALYSIS, COLLOM GULCH SITE

This appendix contains the results of coal analysis prepared by a private consultant, Geochemical Testing, under contract with the U.S. Geological Survey. Coal samples analyzed were from Bureau of Reclamation drill holes numbers 1 through 5 and included 19 samples as shown on the following pages.

Coal analysis report1/
Field ID: DH 2-A

	As received	Dry	Dry ash free
Proximate analysis			
Moisture	14.71		
Ash	24.61	28.86	
Volatile matter	26.09	30.59	43.00
Fixed carbon	34.59	40.55	57.00
	100.00	100.00	100.00
Ultimate analysis			
Hydrogen	4.85	3.75	5.27
Carbon	45.16	52.95	74.43
Nitrogen	1.26	1.48	2.08
Sulfur	.64	.75	1.05
Oxygen	23.48	12.21	17.17
Ash	24.61	28.86	
	100.00	100.00	100.00
Heating value (Btu/lb)	7834	9185	12911
Forms of sulfur			
Sulfate	0.03	0.04	0.06
Pyritic	.13	.15	.21
Organic	.48	.56	.78
Free swelling index	0.0		
Ash fusion temperatures (reducing atmosphere)			
Initial deformation	2550 F		
Softening temperature	2710 F		
Fluid temperature	2760 F		

1/ USGS Lab. No.: D240952
Lab. No.: U10828
Air dry loss: 9.64
State: Colorado
Depth (feet): 185.1-186.9
Residual moisture: 5.61

Coal analysis report[1/]
Field ID: DH 2-B

	As received	Dry	Dry ash free
Proximate analysis			
Moisture	12.31		
Ash	13.48	15.37	
Volatile matter	32.26	36.78	43.46
Fixed carbon	41.95	47.85	56.54
	100.00	100.00	100.00
Ultimate analysis			
Hydrogen	5.16	4.31	5.09
Carbon	55.29	63.05	74.50
Nitrogen	1.45	1.66	1.96
Sulfur	.34	.39	.46
Oxygen	24.28	15.22	17.99
Ash	13.48	15.37	
	100.00	100.00	100.00
Heating value (Btu/lb)	9490	10822	12788
Forms of sulfur			
Sulfate	0.02	0.02	0.02
Pyritic	.04	.04	.05
Organic	.28	.33	.39
Free swelling index	0.0		
Ash fusion temperatures (reducing atmosphere)			
Initial deformation	2690 F		
Softening temperature	2800+ F		
Fluid temperature	2800+ F		

1/ USGS Lab. No.: D240953
Lab. No.: U10829
Air dry loss: 7.12
State: Colorado
Depth (feet): 228.0-233.4
Residual moisture: 5.59

Coal analysis report[1/]
Field ID: DH 2-C

	As received	Dry	Dry ash free
Proximate analysis			
Moisture	13.65		
Ash	6.52	7.55	
Volatile matter	32.70	37.87	40.96
Fixed carbon	47.13	54.58	59.04
	100.00	100.00	100.00
Ultimate analysis			
Hydrogen	5.66	4.79	5.18
Carbon	60.15	69.66	75.35
Nitrogen	1.52	1.77	1.91
Sulfur	.43	.50	.54
Oxygen	25.72	15.73	17.02
Ash	6.52	7.55	
	100.00	100.00	100.00
Heating value (Btu/lb)	10495	12154	13147
Forms of sulfur			
Sulfate	0.00	0.00	0.00
Pyritic	.04	.04	.04
Organic	.39	.46	.50
Free swelling index	0.0		
Ash fusion temperatures (reducing atmosphere)			
Initial deformation	2260 F		
Softening temperature	2350 F		
Fluid temperature	2410 F		

1/ USGS Lab. No.: D240954
Lab. No.: U10830
Air dry loss: 7.85
State: Colorado
Depth (feet): 276.9-278.8
Residual moisture: 6.29

Coal analysis report[1/]
Field ID: DH 2-D

	As received	Dry	Dry ash free
Proximate analysis			
Moisture	14.35		
Ash	11.07	12.93	
Volatile matter	30.39	35.48	40.75
Fixed carbon	44.19	51.59	59.25
	100.00	100.00	100.00
Ultimate analysis			
Hydrogen	5.43	4.47	5.13
Carbon	56.29	65.72	75.48
Nitrogen	1.50	1.75	2.01
Sulfur	.39	.45	.52
Oxygen	25.32	14.68	16.86
Ash	11.07	12.93	
	100.00	100.00	100.00
Heating value (Btu/lb)	9779	11417	13112
Forms of sulfur			
Sulfate	0.01	0.01	0.01
Pyritic	.02	.02	.02
Organic	.36	.42	.49
Free swelling index	0.0		
Ash fusion temperatures (reducing atmosphere)			
Initial deformation	2440 F		
Softening temperature	2550 F		
Fluid temperature	2590 F		

1/ USGS Lab. No.: D240955
Lab. No.: U10831
Air dry loss: 8.49
State: Colorado
Depth (feet): 300.4-301.8
Residual moisture: 6.40

Coal analysis report[1/]
Field ID: DH 3-A

	As received	Dry	Dry ash free
Proximate analysis			
Moisture	16.41		
Ash	9.77	11.69	
Volatile matter	31.81	38.05	43.09
Fixed carbon	42.01	50.26	56.91
	100.00	100.00	100.00
Ultimate analysis			
Hydrogen	5.62	4.52	5.12
Carbon	56.11	67.13	76.02
Nitrogen	1.43	1.71	1.94
Sulfur	.35	.42	.48
Oxygen	26.72	14.53	16.44
Ash	9.77	11.69	
	100.00	100.00	100.00
Heating value (Btu/lb)	9670	11568	13099
Forms of sulfur			
Sulfate	0.02	0.02	0.02
Pyritic	.03	.04	.05
Organic	.30	.36	.41
Free swelling index	0.0		
Ash fusion temperatures (reducing atmosphere)			
Initial deformation	2480 F		
Softening temperature	2620 F		
Fluid temperature	2660 F		

1/ USGS Lab. No.: D240956
Lab. No.: U10832
Air dry loss: 11.37
State: Colorado
Depth (feet): 120.8-126.1
Residual moisture: 5.69

Coal analysis report[1/]
Field ID: DH 3-C

	As received	Dry	Dry ash free
Proximate analysis			
Moisture	15.55		
Ash	8.77	10.39	
Volatile matter	32.08	37.99	42.39
Fixed carbon	43.60	51.62	57.61
	100.00	100.00	100.00
Ultimate analysis			
Hydrogen	5.74	4.73	5.28
Carbon	57.09	67.60	75.44
Nitrogen	1.51	1.79	2.00
Sulfur	.38	.45	.50
Oxygen	26.51	15.04	16.78
Ash	8.77	10.39	
	100.00	100.00	100.00
Heating value (Btu/lb)	9909	11734	13094
Forms of sulfur			
Sulfate	0.00	0.00	0.00
Pyritic	.05	.05	.06
Organic	.33	.40	.44
Free swelling index	0.0		
Ash fusion temperatures (reducing atmosphere)			
Initial deformation	2310 F		
Softening temperature	2400 F		
Fluid temperature	2420 F		

1/ USGS Lab. No.: D240957
Lab. No.: U10833
Air dry loss: 9.80
State: Colorado
Depth (feet): 200.6-202.4
Residual moisture: 6.38

Coal analysis report 1/
Field ID: DH 3-D

	As received	Dry	Dry ash free
Proximate analysis			
Moisture	12.81		
Ash	20.75	23.79	
Volatile matter	28.87	33.11	43.45
Fixed carbon	37.57	43.10	56.55
	100.00	100.00	100.00
Ultimate analysis			
Hydrogen	4.99	4.08	5.35
Carbon	49.97	57.31	75.20
Nitrogen	1.31	1.50	1.97
Sulfur	.47	.54	.71
Oxygen	22.51	12.78	16.77
Ash	20.75	23.79	
	100.00	100.00	100.00
Heating value (Btu/lb)	8605	9869	12951
Forms of sulfur			
Sulfate	0.01	0.01	0.01
Pyritic	.05	.06	.08
Organic	.41	.47	.62
Free swelling index	0.0		
Ash fusion temperatures (reducing atmosphere)			
Initial deformation	2600 F		
Softening temperature	2700 F		
Fluid temperature	2740 F		

1/ USGS Lab. No.: D240958
Lab. No.: U10834
Air dry loss: 7.67
State: Colorado
Depth (feet): 245.5-248.0
Residual moisture: 5.56

Coal analysis report[1/]
Field ID: DH 3-E

	As received	Dry	Dry ash free
Proximate analysis			
Moisture	16.66		
Ash	2.68	3.22	
Volatile matter	32.99	39.58	40.90
Fixed carbon	47.67	57.20	59.10
	100.00	100.00	100.00
Ultimate analysis			
Hydrogen	5.90	4.84	5.00
Carbon	61.59	73.90	76.36
Nitrogen	1.53	1.84	1.90
Sulfur	.32	.38	.39
Oxygen	27.98	15.82	16.35
Ash	2.68	3.22	
	100.00	100.00	100.00
Heating value (Btu/lb)	10610	12731	13155
Forms of sulfur			
Sulfate	0.01	0.01	0.01
Pyritic	.02	.02	.02
Organic	.29	.35	.36
Free swelling index	0.0		
Ash fusion temperatures (reducing atmosphere)			
Initial deformation	2030 F		
Softening temperature	2150 F		
Fluid temperature	2220 F		

1/ USGS Lab. No.: D240959
Lab. No.: U10835
Air dry loss: 10.68
State: Colorado
Depth (feet): 259.7-261.9
Residual moisture: 6.70

Coal analysis report[1/]
Field ID: DH 1-A

	As received	Dry	Dry ash free
Proximate analysis			
Moisture	17.20		
Ash	12.25	14.80	
Volatile matter	30.97	37.41	43.91
Fixed carbon	39.58	47.79	56.09
	100.00	100.00	100.00
Ultimate analysis			
Hydrogen	5.52	4.35	5.11
Carbon	53.28	64.35	75.53
Nitrogen	1.55	1.87	2.19
Sulfur	.51	.61	.72
Oxygen	26.89	14.02	16.45
Ash	12.25	14.80	
	100.00	100.00	100.00
Heating value (Btu/lb)	9151	11052	12972
Forms of sulfur			
Sulfate	.02	.03	.04
Pyritic	.11	.14	.16
Organic	.38	.44	.52
Free swelling index	0.0		
Ash fusion temperatures (reducing atmosphere)			
Initial deformation	2360 F		
Softening temperature	2480 F		
Fluid temperature	2520 F		

1/ USGS Lab. No.: D240960
Lab. No.: U10836
Air dry loss: 11.04
State: Colorado
Depth (feet): 222.4-225.1
Residual moisture: 6.92

Coal analysis report1/
Field ID: DH 1-B

	As received	Dry	Dry ash free
Proximate analysis			
Moisture	16.66		
Ash	4.01	4.81	
Volatile matter	32.05	38.45	40.39
Fixed carbon	47.28	56.74	59.61
	100.00	100.00	100.00
Ultimate analysis			
Hydrogen	5.87	4.80	5.04
Carbon	60.36	72.42	76.08
Nitrogen	1.62	1.94	2.04
Sulfur	.43	.52	.55
Oxygen	27.71	15.51	16.29
Ash	4.01	4.81	
	100.00	100.00	100.00
Heating value (Btu/lb)	10367	12439	13067
Forms of sulfur			
Sulfate	0.01	0.01	0.01
Pyritic	.09	.11	.12
Organic	.33	.40	.42
Free swelling index	0.0		
Ash fusion temperatures (reducing atmosphere)			
Initial deformation	2360 F		
Softening temperature	2440 F		
Fluid temperature	2500 F		

1/ USGS Lab. No.: D240961
Lab. No.: U10837
Air dry loss: 11.14
State: Colorado
Depth (feet): 240.0-243.2
Residual moisture: 6.22

Coal analysis report[1/]
Field ID: DH 5-A

	As received	Dry	Dry ash free
Proximate analysis			
Moisture	18.08		
Ash	4.60	5.62	
Volatile matter	32.27	39.39	41.73
Fixed carbon	45.05	54.99	58.27
	100.00	100.00	100.00
Ultimate analysis			
Hydrogen	5.98	4.83	5.12
Carbon	58.30	71.17	75.40
Nitrogen	1.52	1.85	1.96
Sulfur	.35	.43	.46
Oxygen	29.25	16.10	17.06
Ash	4.60	5.62	
	100.00	100.00	100.00
Heating value (Btu/lb)	10069	12291	13022
Forms of sulfur			
Sulfate	0.00	0.00	0.00
Pyritic	.01	.02	.02
Organic	.34	.41	.44
Free swelling index	0.0		
Ash fusion temperatures (reducing atmosphere)			
Initial deformation	2500 F		
Softening temperature	2590 F		
Fluid temperature	2630 F		

1/ USGS Lab. No.: D240962
Lab. No.: U10838
Air dry loss: 11.68
State: Colorado
Depth (feet): 109.6-115.1
Residual moisture: 7.25

Coal analysis report1/
Field ID: DH 5-C

	As received	Dry	Dry ash free
Proximate analysis			
Moisture	17.33		
Ash	5.94	7.19	
Volatile matter	31.91	38.59	41.58
Fixed carbon	44.82	54.22	58.42
	100.00	100.00	100.00
Ultimate analysis			
Hydrogen	5.76	4.63	4.99
Carbon	58.55	70.82	76.30
Nitrogen	1.39	1.68	1.81
Sulfur	.34	.41	.44
Oxygen	28.02	15.27	16.46
Ash	5.94	7.19	
	100.00	100.00	100.00
Heating value (Btu/lb)	10019	12119	13057
Forms of sulfur			
Sulfate	0.01	0.01	0.01
Pyritic	.02	.03	.03
Organic	.31	.37	.40
Free swelling index	0.0		
Ash fusion temperatures (reducing atmosphere)			
Initial deformation	2560 F		
Softening temperature	2700 F		
Fluid temperature	2740 F		

1/ USGS Lab. No.: D240963
Lab. No.: U10839
Air dry loss: 10.34
State: Colorado
Depth (feet): 157.7-161.5
Residual moisture: 7.80

Coal analysis report1/
Field ID: DH 5-D

	As received	Dry	Dry ash free
Proximate analysis			
Moisture	17.79		
Ash	8.54	10.39	
Volatile matter	33.45	40.69	45.41
Fixed carbon	40.22	48.92	54.59
	100.00	100.00	100.00
Ultimate analysis			
Hydrogen	5.55	4.33	4.83
Carbon	55.56	67.59	75.43
Nitrogen	1.40	1.70	1.90
Sulfur	.42	.51	.57
Oxygen	28.53	15.48	17.27
Ash	8.54	10.39	
	100.00	100.00	100.00
Heating value (Btu/lb)	9534	11597	12942
Forms of sulfur			
Sulfate	0.00	0.00	0.00
Pyritic	.04	.05	.06
Organic	.38	.46	.51
Free swelling index	0.0		
Ash fusion temperatures (reducing atmosphere)			
Initial deformation	2400 F		
Softening tempterature	2500 F		
Fluid temperature	2550 F		

1/ USGS Lab. No.: D240964
Lab. No.: U10840
Air dry loss: 11.33
State: Colorado
Depth (feet): 195.6-199.7
Residual moisture: 7.28

Coal analysis report[1/]
Field ID: DH 5-E

	As received	Dry	Dry ash free
Proximate analysis			
Moisture	13.70		
Ash	25.72	29.81	
Volatile matter	27.93	32.36	46.10
Fixed carbon	32.65	37.83	53.90
	100.00	100.00	100.00
Ultimate analysis			
Hydrogen	4.97	3.98	5.67
Carbon	44.26	51.29	73.07
Nitrogen	1.11	1.29	1.84
Sulfur	.40	.46	.66
Oxygen	23.54	13.17	18.76
Ash	25.72	29.81	
	100.00	100.00	100.00
Heating value (Btu/lb)	7705	8928	12719
Forms of sulfur			
Sulfate	0.01	0.02	0.03
Pyritic	.06	.07	.10
Organic	.33	.37	.53
Free swelling index	0.0		
Ash fusion temperatures (reducing atmosphere)			
Initial deformation	2800+ F		
Softening temperature	2800+ F		
Fluid temperature	2800+ F		

1/ USGS Lab. No.: D240965
Lab. No.: U10841
Air dry loss: 8.74
State: Colorado
Depth (feet): 228.7-232.0
Residual moisture: 5.44

Coal analysis report[1/]
Field ID: DH 5-F

	As received	Dry	Dry ash free
Proximate analysis			
Moisture	17.16		
Ash	14.32	17.28	
Volatile matter	30.51	36.83	44.53
Fixed carbon	38.01	45.89	55.47
	100.00	100.00	100.00
Ultimate analysis			
Hydrogen	5.46	4.27	5.16
Carbon	51.45	62.10	75.08
Nitrogen	1.22	1.47	1.78
Sulfur	.54	.66	.80
Oxygen	27.01	14.22	17.18
Ash	14.32	17.28	
	100.00	100.00	100.00
Heating value (Btu/lb)	8946	10799	13056
Forms of sulfur			
Sulfate	0.04	0.05	0.06
Pyritic	.09	.11	.13
Organic	.41	.50	.61
Free swelling index	0.0		
Ash fusion temperatures (reducing atmosphere)			
Initial deformation	2450 F		
Softening temperature	2570 F		
Fluid temperature	2610 F		

1/ USGS Lab. No.: D240966
Lab. No.: U10842
Air dry loss: 11.28
State: Colorado
Depth (feet): 238.4-249.1
Residual moisture: 6.62

Coal analysis report[1/]
Field ID: DH 5-G

	As received	Dry	Dry ash free
Proximate analysis			
Moisture	16.62		
Ash	4.62	5.55	
Volatile matter	33.17	39.78	42.12
Fixed carbon	45.59	54.67	57.88
	100.00	100.00	100.00
Ultimate analysis			
Hydrogen	6.16	5.16	5.46
Carbon	59.63	71.52	75.72
Nitrogen	1.34	1.60	1.69
Sulfur	.49	.58	.61
Oxygen	27.76	15.59	16.52
Ash	4.62	5.55	
	100.00	100.00	100.00
Heating value (Btu/lb)	10357	12421	13150
Forms of sulfur			
Sulfate	0.01	0.01	0.01
Pyritic	.03	.04	.04
Organic	.45	.53	.56
Free swelling index	0.0		
Ash fusion temperatures (reducing atmosphere)			
Initial deformation	2320 F		
Softening temperature	2400 F		
Fluid temperature	2440 F		

1/ USGS Lab. No.: D240967
Lab. No.: U10843
Air dry loss: 9.50
State: Colorado
Depth (feet): 285.7-291.9
Residual moisture: 7.86

Coal analysis report[1]
Field ID: DH 4-A

	As received	Dry	Dry ash free
Proximate analysis			
Moisture	16.43		
Ash	6.91	8.27	
Volatile matter	33.55	40.15	43.77
Fixed carbon	43.11	51.58	56.23
	100.00	100.00	100.00
Ultimate analysis			
Hydrogen	5.73	4.65	5.07
Carbon	58.24	69.69	75.97
Nitrogen	1.48	1.77	1.93
Sulfur	.31	.37	.40
Oxygen	27.33	15.25	16.63
Ash	6.91	8.27	
	100.00	100.00	100.00
Heating value (Btu/lb)	10055	12032	13117
Forms of sulfur			
Sulfate	0.01	0.01	0.01
Pyritic	.03	.04	.04
Organic	.27	.32	.35
Free swelling index	0.0		
Ash fusion temperatures (reducing atmosphere)			
Initial deformation	2670 F		
Softening temperature	2750 F		
Fluid temperature	2790 F		

1/ USGS Lab. No.: D240968
Lab. No.: U10844
Air dry loss: 10.04
State: Colorado
Depth (feet): 73.5-76.6
Residual moisture: 7.11

Coal analysis report 1/
Field ID: DH 4-B

	As received	Dry	Dry ash free
Proximate analysis			
Moisture	17.40		
Ash	2.59	3.14	
Volatile matter	33.84	40.97	42.30
Fixed carbon	46.17	55.89	57.70
	100.00	100.00	100.00
Ultimate analysis			
Hydrogen	5.91	4.80	4.96
Carbon	60.34	73.06	75.43
Nitrogen	1.61	1.95	2.01
Sulfur	.42	.51	.53
Oxygen	29.13	16.54	17.07
Ash	2.59	3.14	
	100.00	100.00	100.00
Heating value (Btu/lb)	10309	12480	12884
Forms of sulfur			
Sulfate	0.02	0.03	0.03
Pyritic	.04	.04	.04
Organic	.36	.44	.46
Free swelling index	0.0		
Ash fusion temperatures (reducing atmosphere)			
Initial deformation	2120 F		
Softening temperature	2200 F		
Fluid temperature	2230 F		

1/ USGS Lab. No.: D240969
Lab. No.: U10845
Air dry loss: 10.48
State: Colorado
Depth (feet): 108.5-110.7
Residual moisture: 7.73

Coal analysis report[1/]
Field ID: DH 4-C

	As received	Dry	Dry ash free
Proximate analysis			
Moisture	16.49		
Ash	7.45	8.92	
Volatile matter	33.63	40.27	44.21
Fixed carbon	42.43	50.81	55.79
	100.00	100.00	100.00
Ultimate analysis			
Hydrogen	5.76	4.69	5.15
Carbon	57.90	69.34	76.13
Nitrogen	1.47	1.76	1.93
Sulfur	.34	.41	.45
Oxygen	27.08	14.88	16.34
Ash	7.45	8.92	
	100.00	100.00	100.00
Heating value (Btu/lb)	9791	11724	12872
Forms of sulfur			
Sulfate	0.04	0.04	0.04
Pyritic	.02	.02	.02
Organic	.28	.35	.39
Free swelling index	0.0		
Ash fusion temperatures (reducing atmosphere)			
Initial deformation	2410 F		
Softening temperature	2490 F		
Fluid temperature	2510 F		

1/ USGS Lab. No.: D240970
Lab. No.: U10846
Air dry loss: 9.08
State: Colorado
Depth (feet): 149.0-153.4
Residual moisture: 8.15

APPENDIX C

SOILS AND OVERBURDEN

Characterization of Soil and Overburden Material of the Collom Gulch Study Area

This appendix contains the supporting data utilized in the characterization of the soil and overburden material at the Collom Gulch study site. It includes summary data sheets of laboratory analysis of soil and overburden and land classification maps of the study site.

United States Department of the Interior
Bureau of Reclamation
Upper Colorado Region
Salt Lake City, Utah

APPENDIX C

SOILS AND OVERBURDEN

The following soil profiles are typical of the various classes of soil suitable for stockpiling as a plant growth media. Most soils are residual from the underlying parent material. They vary in depth with the deeper profiles typical of class 2 lands and the shallower profile typical of most class 3 lands.

Laboratory data sheets are included for each typical profile and surface material of drill holes 1 through 3. This included complete analysis on 24 samples and 528 determinations. Screening tests were run on 347 samples from the sampled Texoma power auger and hand auger holes dug during the field investigations.

Included in this appendix are six photographs of the area.

Table 6 presents data in determination of suitability of the geologic overburden as plant growth media.

TYPICAL SOIL PROFILE

Table 1

Sheet 1 of 3

PROJECT EMRIA AREA Collom Gulch, Colo. LAND CLASS

LOCATION Sec. 32, T. 4 N., R. 94 W. VEGETATION Sagebrush and native grasses

TOPOGRAPHY Sloping (5%) ridgetop DRAINAGE Medium

SOILS TP-1 residual

		Soil Description										Chemical and Physical Properties							
		Color		Texture				Consistence				Chemical				Physical			
Horiz-on	Depth (feet)	Dry	Moist	PSA -2mm %si / %c	Soil Log	+2mm mat. (% by vol.)	Struct-ure	Dry	Moist	Wet	Other Characteristics	EC (mmhos /cm)	pH paste 1:5	CEC (me / 100gm)	ESP (%) SAR (calc)	Bulk density (gm / cc)	Pore space (%)	Infilt. (in / hr)	Avail. moist. (in / depth)
	0 to 0.25	5 YR 3/3	5 YR 3/4				Weak, fine crumb	Soft	Friable	Slightly plastic, slightly sticky	Moderate permeability.	0.675		16.00	0.5 .3				
	0.25 to 0.9	5 YR 3/3	5 YR 3/4		2'		Strong, fine, subangular blocky	Hard	Firm	Plastic sticky	Moderately slow permeability.	.511		25.81	.5 .2				
	0.9 to 2.1	7.5 YR 3/2	7.5 YR 4/4				Strong, medium prismatic	Very hard	Firm	Plastic sticky	Moderately slow permeability.	.287		27.50	.4 .3				
	2.1 to 2.9	7.5 YR 4/4	7.5 YR 5/6		4'		Moderately subangular blocky	Very hard	Firm		Slow permeability. Weather shale and silty clay.	.326		25.06	.9 .3				
	2.9 to 6.0	10 YR 6/1	10 YR 4/1		6'		Moderately subangular blocky	Hard		Sticky plastic	Shale and clay. Shale at 6'.	.326		23.94	1.8 .9				
					8'														

TYPICAL SOIL PROFILE

Table 1

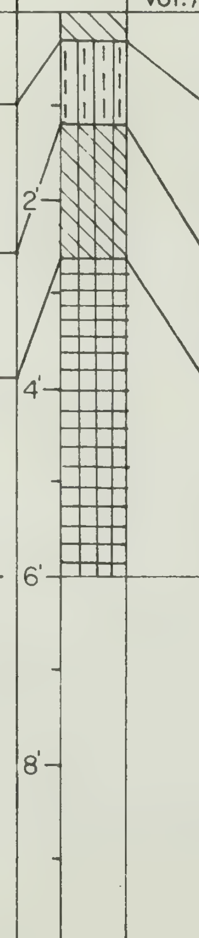
Sheet 2 of 3

PROJECT EMRIA AREA Collom Gulch, Colo. LAND CLASS

LOCATION Sec. 27, T. 4 N., R. 94 W. VEGETATION Sagebrush and native grasses

TOPOGRAPHY Gently sloping (3%) ridgetop DRAINAGE Medium

SOILS TP-2 (AH-10) residual

Horizon	Depth (feet)	Soil Description										Chemical and Physical Properties							
		Color		Texture			Structure	Consistence			Other Characteristics	Chemical				Physical			
		Dry	Moist	PSA -2mm %si / %c	Soil Log	+2mm mat. (% by vol.)		Dry	Moist	Wet		EC (mmhos /cm)	pH paste 1:5	CEC (me / 100gm)	ESP (%) SAR (calc)	Bulk density (gm / cc)	Pore space (%)	Infilt. (in / hr)	Avail. moist. (in / depth)
A	0 to 0.3	7.5 YR 5/2	5 YR 3/4				Weak, fine crumb	Loose	Friable	Slightly sticky, slightly plastic	Moderate permeability.	0.823		22.50	0.8 .3				
B	0.3 to 1.2	5 YR 3/3	5 YR 3/3				Strong, medium, subangular blocky	Hard	Firm	Plastic sticky	Moderately slow permeability.	.714		25.62	.2 .3				
	1.2 to 2.6	5 YR 3/2	5 YR 3/2				Strong, medium prismatic	Hard	Firm	Plastic, slightly sticky	Slow permeability. Black shale and clay.	.560		38.31	.4 .3				
	2.6 to 6.0	Variegated shale									Very slow permeability.	.924		16.13	3.1 1.9				

TYPICAL SOIL PROFILE

Table 1

PROJECT EMRIA AREA Collom Gulch, Colo. LAND CLASS Sheet 3 of 3
LOCATION Sec. 34, T. 4 N., R. 94 W. VEGETATION Sagebrush and native grasses
TOPOGRAPHY High sideslope (8%) DRAINAGE Rapid
SOILS TP-3 (AH-14) residual

Horiz-on	Depth (feet)	Soil Description										Chemical and Physical Properties							
		Color		Texture			Struct-ure	Consistence			Other Characteristics	Chemical				Physical			
		Dry	Moist	PSA -2mm %si / %c	Soil Log	+2mm mat. (% by vol.)		Dry	Moist	Wet		EC (mhos /cm)	pH paste 1:5	CEC (me / 100gm)	ESP (%) SAR (calc)	Bulk density (gm / cc)	Pore space (%)	Infilt. (in / hr)	Avail. moist. (in / depth)
A	0 to 0.2	5 YR 4/3	5 YR 4/3				Weak, fine crumb	Loose	Friable	Slightly plastic, slightly sticky	Moderate permeability.	0.904		16.69	1.0 .4				
B	0.2 to 0.6	5 YR 4/4	5 YR 4/4		2'		Strong, subangular blocky	Hard	Very firm	Plastic sticky	Weakly cemented. Slow permeability.	.410		21.37	.8 .3				
	0.6 to 1.2	5 YR 4/4	5 YR 4/4				Moderately coarse, subangular blocky	Hard	Firm	Plastic sticky	Weakly cemented. Slow permeability. Numerous sandstone fragments to 6'.	.646		26.50	.8 .3				
	1.2 to 2.2	5 YR 4/4	5 YR 4/4		4'		Strong, medium prismatic	Hard	Firm	Plastic sticky	Slow permeability.	.469		18.75	2.9 2.8				
	2.2 to 4.5	Variegated shale					Very weak, medium columnar	Extra hard	Extra firm		Very slow permeability.								
					6' 8'														

View of drill hole site number 3, representing typical class 2 lands.

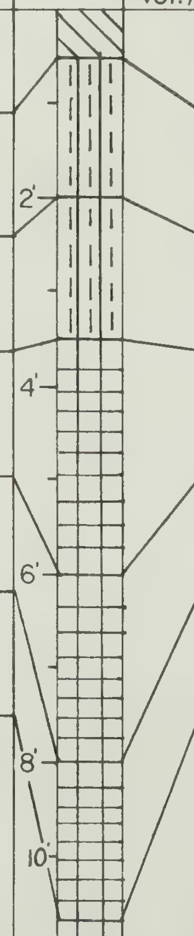
View of alluvial bottoms with Morgan Gulch pond in middle distance. These typical class 1 lands should not be disturbed or recommended for use as plant growth medium.

TYPICAL SOIL PROFILE

Table 2, Sheet 1 of 5
Drill Hole #1

PROJECT Collom Gulch AREA Collom Gulch, Colo. LAND CLASS
LOCATION Sec. 32, T. 4 N., R. 94 W. VEGETATION
TOPOGRAPHY DRAINAGE
SOILS

Horiz-on	Depth (feet)	Soil Description: Color: Dry	Color: Moist	Texture: PSA -2mm %si / %c	Texture: Soil Log	Texture: +2mm mat. (% by vol.)	Structure	Consistence: Dry	Consistence: Moist	Consistence: Wet	Other Characteristics	Chemical and Physical Properties: Chemical: EC (mhos/cm)	Chemical: pH paste 1:5	Chemical: CEC (me/100gm)	Chemical: ESP (%) / SAR (calc)	Physical: Bulk density (gm/cc)	Physical: Pore space (%)	Physical: Infilt. (in/hr)	Physical: Avail. moist. (in/depth)
A1	0 to 0.5			33.6 / 36.0							Clay loam	0.883	8.4	24.4	0.2 / .2				
B1	0.5 to 2.0			29.2 / 54.2							Clay	.494	8.8	29.8	.7 / .4				
	2.0 to 3.5			23.4 / 60.6							Clay	.702	8.7	33.8	2.1 / 1.5				
	3.5 to 6.0			10.1 / 80.1							Shale	7.58	8.3	38.3	2.7 / 2.7				
	6.0 to 8.0			22.4 / 68.4							Shale	7.09	8.3	34.7	2.2 / 2.2				
	8.0 to 11.7			35.0 / 56.0							Shale	4.29	8.1	29.9	2.2 / 1.6				
	11.7 to 13.0			34.2 / 48.2							Shale	5.56	8.5	18.6	3.0 / 1.2				



TYPICAL SOIL PROFILE

Table 2, Sheet 2 of 5
Drill Hole #2

PROJECT EMRIA AREA Collom Gulch, Colo. LAND CLASS
LOCATION VEGETATION Sagebrush and native grasses
TOPOGRAPHY Ridgetop, 3 to 4% slope DRAINAGE
SOILS

Horiz-on	Depth (feet)	Soil Description: Color: Dry	Color: Moist	Texture: PSA -2mm %si/%c	Texture: Soil Log	Texture: +2mm mat. (% by vol.)	Struct-ure	Consistence: Dry	Consistence: Moist	Consistence: Wet	Other Characteristics	Chemical and Physical Properties: Chemical: EC (mhos/cm)	pH paste 1:5	CEC (me/100gm)	ESP (%) SAR (calc)	Physical: Bulk density (gm/cc)	Pore space (%)	Infilt. (in/hr)	Avail. moist. (in/depth)
	0 to 0.5			41.8 / 34.8							Clay loam	0.842	8.4	16.25	1.1 / .7				
	0.5 to 3.0			34.2 / 50.0	2'						Clay	.863	8.8	20.31	5.6 / 3.3				
	3.0 to 5.0			27.2 / 65.6	4'						Shale (clay)	10.4	8.1	25.88	8.5 / 7.0				
	5.0 to 7.0			33.6 / 17.8							Sandstone (loam)	7.19	8.2	8.31	6.3 / 5.6				
					6' 8'														

TYPICAL SOIL PROFILE

Table 2, Sheet 3 of 5

Drill Hole #3

PROJECT EMRIA AREA Collom Gulch, Colo. LAND CLASS

LOCATION Sec. 34, T. 4 N., R. 94 W. VEGETATION Thick stand of sagebrush and native grasses

TOPOGRAPHY 5% sideslope DRAINAGE

SOILS

Horiz-on	Depth (feet)	Soil Description: Color: Dry	Color: Moist	Texture: PSA -2mm %si / %c	Texture: Soil Log	Texture: +2mm mat. (% by vol.)	Structure	Consistence: Dry	Consistence: Moist	Consistence: Wet	Other Characteristics	Chemical and Physical Properties: Chemical: EC (mhos /cm)	Chemical: pH paste 1:5	Chemical: CEC (me / 100gm)	ESP (%) / SAR (calc)	Physical: Bulk density (gm / cc)	Physical: Pore space (%)	Physical: Infilt. (in / hr)	Physical: Avail. moist. (in / depth)
	0-1			38.6 / 22.2							Loam	0.500	8.1	17.75	1.3 / .2				
	1-2			21.2 / 20.8							Sandy, clay loam	.366	8.3	9.69	2.4 / .3				
	2-4			28.2 / 51.2	2'						Moist, grey shale	.344	8.5	30.25	.7 / .4				
	4-5			36.4 / 54.0							Red-brown shale	.273	8.6	28.63	2.0 / .7				
	5-6			44.6 / 38.2	4'						Grey shale	.333	8.5	20.31	2.6 / 1.3				
	6-10			40.6 / 35.2							Grey shale	.343	8.4	19.69	2.7 / 1.2				
	10-13			42.6 / 50.4	6'						Grey shale	.331	8.8	26.25					
	13-14			48.0 / 38.2	8						Red-brown shale	.434	8.7	21.25					
	14-17			38.8 / 50.2							Grey shale	.372	8.7	25.81					

TYPICAL SOIL PROFILE

Table 2, Sheet 4 of 5

Drill Hole #4

PROJECT EMRIA AREA Collom Gulch, Colo. LAND CLASS

LOCATION Sec. 3, T. 4 N., R. 94 W . VEGETATION Sagebrush, snowberry, native grasses

TOPOGRAPHY Ridgetop, 6% slope DRAINAGE Moderately rapid surface

SOILS

Horiz-on	Depth (feet)	Soil Description										Chemical and Physical Properties							
		Color		Texture			Struct-ure	Consistence			Other Characteristics	Chemical				Physical			
		Dry	Moist	PSA -2mm %si / %c	Soil Log	+2mm mat. (% by vol.)		Dry	Moist	Wet		EC (mhos /cm)	pH paste 1:5	CEC (me / 100gm)	ESP (%) SAR (calc)	Bulk density (gm / cc)	Pore space (%)	Infilt. (in / hr)	Avail. moist. (in / depth)
	0-1			45.4 / 29.4							Clay loam	0.442	8.4	19.63					
	1-2			49.2 / 24.8	2'						Loam	.409	8.5	12.31					
	2-4			52.8 / 16.8	4'						Siltstone (silt loam)	.349	8.4	6.75					
	4-6			45.0 / 12.8	6'						Siltstone (loam)	.322	8.5	4.06					
	6-9			43.6 / 12.8	8'						Siltstone (loam)	.313	8.5	3.88					

TYPICAL SOIL PROFILE

Table 2, Sheet 5 of 5

PROJECT EMRIA AREA Collom Gulch, Colo. LAND CLASS Drill Hole #5
LOCATION Sec. 6, T. 3 N., R. 94 W. VEGETATION Sagebrush, rabbitbrush, native grasses
TOPOGRAPHY Sideslope DRAINAGE Moderately rapid surface
SOILS

Horizon	Depth (feet)	Soil Description: Color: Dry	Color: Moist	Texture: PSA -2mm %si / %c	Texture: Soil Log	+2mm mat. (% by vol.)	Structure	Consistence: Dry	Consistence: Moist	Consistence: Wet	Other Characteristics	Chemical and Physical Properties: Chemical: EC (mhos/cm)	pH paste 1:5	CEC (me/100gm)	ESP (%) SAR (calc)	Physical: Bulk density (gm/cc)	Pore space (%)	Infilt. (in/hr)	Avail. moist. (in/depth)
	0-1			39.2 / 29.2							Clay loam	3.41	7.7						
	1-2			35.8 / 49.4	2'						Weathered, grey shale and clay	.718	8.5						
	2-5			26.2 / 58.6							Black shale	5.95	8.2						
	5-9			32.0 / 31.8	4'						Grey shale	5.95	8.1						
	9-10			27.0 / 23.4							Shale and sandstone	4.88	8.2						
	10-11			24.2 / 23.2	6'						Weathered, grey sandstone	4.13	8.2						
	11-12.5			19.0 / 15.2	8'						Weathered, yellow sandstone	3.85	8.2						

View of typical class 2 land on broad ridgetops with gentle slopes.

View of typical class 6 lands showing ledge rock and steep, stony slopes. Difficult to strip and stockpile.

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Table 3

ANALYSIS OF SOILS

Project	Collom Gulch, Colo., Federal Coal Management Study
Collected by	Jibson, McCoy — Date September 1980 — Received September 1980
Analyzed by	Jibson — Date February 1981
Location and Class	
Vegetation	

SAMPLE						
Lab No.	545	546	547	548	549	555
Field No.	TP-1	TP-1	TP-1	TP-1	TP-1	TP-2
Depth, inches	0.-0.25	0.25-0.9	0.9-2.1	2.1-2.9	2.9-6.0	0-0.3
Field texture	SiC	SiC	SiC	SiC	Shale-Clay	SiCL
SOIL						
Saturation percentage	40.2	50.1	55.7	51.6	56.5	44.4
pH paste						
pH, 1:5 dilution						
Insoluble carbonates	0	0	0	high	high	low
Gypsum me/100 gm.						
Organic matter, percent						
SATURATION EXTRACT						
Conductivity EC x 10^3 @ 25°C	0.675	0.511	0.287	0.326	0.326	0.823
pH	7.5	7.5	7.5	7.3	7.4	8.0
Dissolved solids p.p.m.	504	384	180	208	224	610
Boron p.p.m.						0
Carbonate me./l	0	0	0	0	0	0
Bicarbonate me./l	6.15	3.75	2.10	2.80	2.30	7.25
Chloride me./l	.30	.25	.25	.10	.10	.65
Sulfate me./l	.71	1.29	.67	.46	.79	1.52
Calcium me./l	3.96	3.36	1.54	1.40	1.16	5.20
Magnesium me./l	1.72	1.60	.88	1.04	1.16	2.80
Sodium me./l	.52	.24	.36	.40	.96	.60
Potassium me./l	1.20	.22	.02	.06	.03	.61
S.A.R.	.3	.2	.3	.3	.9	.3
EXCHANGE RELATIONS						
Total sodium me./100 gm.	.10	.13	.13	.25	.48	.20
Soluble sodium me./100 gm.	.02	.01	.02	.02	.05	.02
Exchangeable sodium me./100 gm.	.08	.12	.11	.23	.43	.18
Cation exchange capacity me./100 gm.	16.00	25.81	27.50	25.06	23.94	22.50
Exchangeable sodium percent	.5	.5	.4	.9	1.8	.8
PARTICLE SIZE ANALYSIS						
Percent > 2 m.m.						
Percent sand .05-2 m.m.	35.4	29.8	29.2	15.2	13.0	26.0
Percent silt .002-.05 m.m.	43.4	31.8	30.0	40.2	45.0	40.8
Percent clay < .002 m.m.	21.2	38.4	40.8	44.6	42.0	33.2
Texture	L	CL	C to CL	SiC	SiC	CL

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Table 3

ANALYSIS OF SOILS

Project	Collom Gulch, Colo., Federal Coal Management Study
Collected by	Jibson, McCoy — Date September 1980 — Received September 1980
Analyzed by	Jibson — Date February 1981
Location and Class	
Vegetation	

SAMPLE						
Lab No.	556	557	558	561	562	563
Field No.	TP-2	TP-2	TP-2	TP-3	TP-3	TP-3
Depth, inches	0.3-1.2	1.2-2.6	2.6-6.0	0.-0.2	0.2-0.6	0.6-1.2
Field texture	SiC	C	Shale	SiCL	C	C
SOIL						
Saturation percentage	50.5	59.2	60.9	44.1	43.8	55.7
pH paste						
pH, 1:5 dilution						
Insoluble carbonates	low	0	medium	0	0	0
Gypsum me/100 gm.						
Organic matter, percent						
SATURATION EXTRACT						
Conductivity $EC \times 10^3$ @ 25°C	0.714	0.560	0.924	0.904	0.410	0.646
pH	8.1	8.2	8.2	7.9	8.1	8.0
Dissolved solids p.p.m.	570	464	630	740	400	688
Boron p.p.m.	0	0	0	0	0	
Carbonate me./l	0	0	0	0	0	0
Bicarbonate me./l	6.05	4.25	1.95	7.75	3.15	4.85
Chloride me./l	.45	.30	3.65	.75	.20	.40
Sulfate me./l	1.04	1.42	3.69	1.72	.71	1.03
Calcium me./l	5.25	3.64	1.80	6.60	2.52	4.12
Magnesium me./l	2.90	2.24	4.55	2.45	1.16	2.20
Sodium me./l	.55	.44	3.35	.75	.44	.52
Potassium me./l	.16	.07	.06	.85	.45	.30
S.A.R.	.3	.3	1.9	.4	.3	.3
EXCHANGE RELATIONS						
Total sodium me./100 gm.	.08	.20	.70	.20	.20	.23
Soluble sodium me./100 gm.	.03	.03	.20	.03	.02	.03
Exchangeable sodium me./100 gm.	.05	.17	.50	.17	.18	.20
Cation exchange capacity me./100 gm.	25.62	38.31	16.13	16.69	21.37	26.50
Exchangeable sodium percent	.2	.4	3.1	1.0	.8	.8
PARTICLE SIZE ANALYSIS						
Percent > 2 m.m.						
Percent sand .05-2 m.m.	22.6	17.4	16.6	30.2	27.4	22.4
Percent silt .002-.05 m.m.	39.6	36.2	45.2	42.6	35.2	29.0
Percent clay < .002 m.m.	37.8	46.4	38.2	27.2	37.4	48.6
Texture	C	C	SiCL	CL	CL	C

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Table 3
ANALYSIS OF SOILS

Project: Collom Gulch, Colo., Federal Coal Management Study

Collected by: McCoy, Jibson   Date: September 1980   Received: September 1980

Analyzed by: Jibson   Date: March 8, 1981

Location and Class:

Vegetation:

SAMPLE						
Lab No.	564	568	569	570	571	575
Field No.	TP-3	DH-1	DH-1	DH-1	DH-1	DH-2
Depth, inches	1.2-2.2	0-0.5	0.5-2	2-3.5	3.5-6	0-0.5
Field texture	C	L	CL	C	Shale	CL
SOIL						
Saturation percentage	45.4	48.8	61.6	64.8	85.6	46.9
pH paste						
pH, 1:5 dilution						
Insoluble carbonates	low	-	high	high	low	none
Gypsum me / 100 gm.						
Organic matter, percent						
SATURATION EXTRACT						
Conductivity EC x 10^3 @ 25°C	0.469	0.883	0.494	0.702	7.53	0.842
pH	8.7	8.4	8.8	8.7	8.3	8.4
Dissolved solids p.p.m.	432	768	440	520	9,650	604
Boron p.p.m.						
Carbonate me./l	.80	.70	0	.40	.20	0
Bicarbonate me./l	3.40	6.70	3.80	3.40	2.00	5.70
Chloride me./l	.35	1.75	.50	1.20	8.50	2.90
Sulfate me./l	.83	1.25	1.00	2.29	118.9	1.25
Calcium me./l	1.30	5.16	2.64	1.72	24.48	4.00
Magnesium me./l	.96	4.04	2.48	3.50	86.00	4.40
Sodium me./l	2.94	.36	.56	2.44	20.00	1.44
Potassium me./l	.07	.54	.09	.07	.45	.44
S.A.R.	2.8	.2	.4	1.5	2.7	.7
EXCHANGE RELATIONS						
Total sodium me./100 gm.	.68	.08	.25	.88	2.75	.25
Soluble sodium me./100 gm.	.13	.02	.03	.16	1.71	.07
Exchangeable sodium me./100 gm.	.55	.06	.22	.72	1.04	.18
Cation exchange capacity me./100 gm.	18.75	24.38	29.81	33.81	38.25	16.25
Exchangeable sodium percent	2.9	.2	.7	2.1	2.7	1.1
PARTICLE SIZE ANALYSIS						
Percent > 2 m.m.						
Percent sand .05 - 2 m.m.	27.4	30.4	16.6	16.0	9.8	23.4
Percent silt .002 - .05 m.m.	39.0	33.6	29.2	23.4	10.1	41.8
Percent clay < .002 m.m.	33.6	36.0	54.2	60.6	80.1	34.8
Texture	CL	CL	C	C	C	CL

Table 3

ANALYSIS OF SOILS

Project	Collom Gulch, Colo., Federal Coal Management Study		
Collected by	McCoy, Jibson	Date September 1980	Received September 1980
Analyzed by	Jibson	Date	
Location and Class			
Vegetation			

SAMPLE						
Lab No.	576	577	578	579	580	581
Field No.	DH-2	DH-2	DH-2	DH-3	DH-3	DH-3
Depth, inches	0.5-3.0	3.0-5.0	5.0-7.0	0-1.0	1.0-2.0	2.0-4.0
Field texture	C	Shale	Sandstone	L	SCL	C
SOIL						
Saturation percentage	62.2	62.8	33.4	58.9	33.7	58.7
pH paste						
pH, 1:5 dilution						
Insoluble carbonates	high	medium	medium	0	0	low
Gypsum me/100 gm.						
Organic matter, percent						
SATURATION EXTRACT						
Conductivity EC x 10³ @ 25°C	0.863	10.4	7.19	0.500	0.366	0.344
pH	8.8	8.1	8.2	8.1	8.3	8.5
Dissolved solids p.p.m.	576					
Boron p.p.m.						
Carbonate me./l	0.50	0	0	0	0.40	0.40
Bicarbonate me./l	4.80	1.95	2.20	3.75	3.20	2.85
Chloride me./l	2.20	48.70	35.00	.35	.15	.25
Sulfate me./l	1.66	99.32	56.94	1.04	.51	.43
Calcium me./l	1.72	29.00	20.50	3.48	2.54	2.00
Magnesium me./l	2.92	72.00	43.00	1.26	1.18	1.44
Sodium me./l	4.96	50.00	31.50	.38	.46	.46
Potassium me./l	.07	.35	.35	.63	.08	.03
S.A.R.	3.3	7.0	5.6	.2	.3	.4
EXCHANGE RELATIONS						
Total sodium me./100 gm.	1.45	5.33	1.57	.25	.25	.25
Soluble sodium me./100 gm.	.31	3.14	1.05	.02	.02	.03
Exchangeable sodium me./100 gm.	1.14	2.19	.52	.23	.23	.22
Cation exchange capacity me./100 gm.	20.31	25.88	8.31	17.75	9.69	30.25
Exchangeable sodium percent	5.6	8.5	6.3	1.3	2.4	.7
PARTICLE SIZE ANALYSIS						
Percent > 2 m.m.						
Percent sand .05-2 m.m.	15.8	7.2	48.6	39.2	58.0	20.6
Percent silt .002-.05 m.m.	34.2	27.2	33.6	38.6	21.2	28.2
Percent clay < .002 m.m.	50.0	65.6	17.8	22.2	20.8	51.2
Texture	C	C	L	L	SCL	C

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Table 3

ANALYSIS OF SOILS

Project	Collom Gulch, Colo., Federal Coal Management Study
Collected by	McCoy, Jibson Date September 1980 Received September 1980
Analyzed by	Jibson Date March 1981
Location and Class	
Vegetation	

SAMPLE						
Lab No.	588	589	590	591		
Field No.	DH-4	DH-4	DH-4	DH-4		
Depth, inches	0-1.0	1.0-2.0	2.0-4.0	4.0-6.0		
Field texture	CL	siltstone	SiCL	SiCL		
SOIL						
Saturation percentage	57.6	42.2	36.5	31.8		
pH paste						
pH, 1:5 dilution						
Insoluble carbonates	0	medium	high	high		
Gypsum me / 100 gm.						
Organic matter, percent						
SATURATION EXTRACT						
Conductivity EC x 10^3 @ 25°C	0.442	0.409	0.349	0.322		
pH	8.4	8.5	8.4	8.5		
Dissolved solids p.p.m.						
Boron p.p.m.						
Carbonate me./l	.20	.20	.20	.30		
Bicarbonate me./l	3.70	3.40	2.70	2.35		
Chloride me./l	.15	.35	.35	.35		
Sulfate me./l						
Calcium me./l						
Magnesium me./l						
Sodium me./l						
Potassium me./l						
S.A.R.						
EXCHANGE RELATIONS						
Total sodium me./100 gm.	.25	.33	.35	.35		
Soluble sodium me./100 gm.						
Exchangeable sodium me./100 gm.						
Cation exchange capacity me./100 gm.	19.63	12.31	6.75	4.06		
Exchangeable sodium percent						
PARTICLE SIZE ANALYSIS						
Percent > 2 m.m.						
Percent sand .05 - 2 m.m.	25.2	26.0	30.4	42.0		
Percent silt .002 - .05 m.m.	45.2	49.2	52.8	45.0		
Percent clay < .002 m.m.	29.4	24.8	16.8	12.8		
Texture	CL	L	SiL	L		

Table 3

ANALYSIS OF SOILS

Project	Collom Gulch, Colo., Federal Coal Management Study				
Collected by	McCoy, Jibson	Date	September 1980	Received	September 1980
Analyzed by	Jibson	Date	March 1981		
Location and Class					
Vegetation					

SAMPLE						
Lab No.	593	594	595	596		
Field No.	DH-5	DH-5	DH-5	DH-5		
Depth, inches	0-1	1-2	2-5	5-9		
Field texture	C	C	shale	shale		
SOIL						
Saturation percentage	47.5	56.4	74.8	46.0		
pH paste						
pH, 1:5 dilution						
Insoluble carbonates	0	medium	0	0		
Gypsum me/100 gm.						
Organic matter, percent						
SATURATION EXTRACT						
Conductivity EC x 10^3 @ 25°C	3.41	0.718	5.95	4.88		
pH	7.7	8.5	8.2	8.1		
Dissolved solids p.p.m.						
Boron p.p.m.						
Carbonate me./l	0	.40	0	0		
Bicarbonate me./l	7.65	2.95	6.10	5.00		
Chloride me./l	7.05	1.95	23.75	25.40		
Sulfate me./l						
Calcium me./l						
Magnesium me./l						
Sodium me./l						
Potassium me./l						
S.A.R.						
EXCHANGE RELATIONS						
Total sodium me./100 gm.						
Soluble sodium me./100 gm.						
Exchangeable sodium me./100 gm.						
Cation exchange capacity me./100 gm.						
Exchangeable sodium percent						
PARTICLE SIZE ANALYSIS						
Percent > 2 m.m.						
Percent sand .05 - 2 m.m.	31.6	14.8	15.2	36.2		
Percent silt .002 - .05 m.m.	39.2	35.8	26.2	32.0		
Percent clay < .002 m.m.	29.2	49.4	58.6	31.8		
Texture	CL	C	C	CL		

View of an exposed coal seam on steep sideslope in a slip or sump area.

View of ridgetop topography. Very recent slump can be seen in the middle distance. Good example of existing vegetation.

Table 4
Sheet 1 of 7

SOILS LABORATORY REPORT

BUREAU OF RECLAMATION
SALT LAKE CITY, UTAH

Collom Gulch, Colo.
EMRIA Coal Study

LAB. No.	Boring Number	Depth in Feet	Field Text.	Hyd. Cond. 6 Hr. in/hr	Hyd. Cond. 24 Hr. in/hr	Tension in Bars 1/3 % Moisture	Tension in Bars 15 % Moisture	Saturation Extract ECe at 25°C.	Na. meq/l	Ca.+ Mg meq/l	K. meq/l	Mg meq/l	SAR True	SAR Ext.	1:5 EC at 25°C	pH at 25°C
600	DH-1	3.5-11.7	shale	.08	.08			3.00	5.6	33.6			1.4		.535	8.2
601	"	11.7-12.2	siltstone	.05	.03			3.61	6.0	41.6			1.3		.595	8.3
602	"	12.2-16.8	shale	.03	.02			3.07	4.4	36.0			1.0		.455	8.2
603	"	16.8-18.7	siltstone	.08	.07			3.68	3.8	62.8			.7		.480	8.2
604	"	18.7-27.0	shale	.05	.05			5.13	4.0	49.5			.8		.796	7.9
605	"	28.1-31.3	shale	.02	.03			2.71	1.8	34.0			.4		.443	7.9
606	"	31.3-37.1	sandstone	.11	.10										.185	8.0
607	"	37.1-46	shale	.05	.05										.247	8.4
608	"	47.5-48.6	shale	.03	.03										.162	8.3
609	"	48.6-49.3	siltstone	.03	.03										.138	8.2
610	"	50-53.6	sandstone	.33	.29										.130	8.1
611	"	53.6-59.5	siltstone	.03	.03										.136	8.1
612	"	59.5-65.0	sandstone	.08	.08										.183	8.2
613	"	65-69.3	siltstone	.05	.05										.195	8.4
614	"	69.3-70.8	sandstone	.08	.08										.164	8.2
615	"	70.8-71.5	shale	.09	.03										.222	8.2
616	"	71.5-72.1	siltstone	.02	.03										.168	8.4
617	"	72.1-72.6	sandstone	.05	.04										.152	8.3
618	"	72.6-73.3	siltstone	.16	.17										.212	8.3
619	"	73.3-76.2	shale	.05	.05										.240	8.3
620	"	76.2-77.4	siltstone	.02	.01										.220	8.4
621	"	77.4-80.8	siltstone	.02	.01										.287	8.3
622	"	80.8-88	sandstone	.03	.03										.150	8.5
623	"	88-105.4	sandstone	.49	.42										.113	8.7
624	"	105.4-105.8	shale	.01	.01										.109	8.3
625	"	105.8-109.9	sandstone	.03	.03										.181	8.5
626	"	109.9-117.5	siltstone	.02	.02										.222	8.3
627	DH-1	117.5-131.5	sandstone	.06	.07										.185	8.4
628		132.1-134.9	sandstone	.06	.06										.155	8.5
629		134.9-141.7	siltstone	.07	.06										.340	8.2
630		144.8-147	siltstone	.10	.08										.167	7.9
631		147-148.7	shale	.03	.04										.258	7.9
632		148.7-150.7	sandstone	.06	.08										.189	
633		150.7-115.9	shale	.07	.09										.234	
634		151.9-152.7	siltstone	.02	.01										.198	
635		152.7-158.1	sandstone	.03	.03										.217	
636		158.1-160.2	shale	.03	.03										.299	
637		160.2-167.5	sandstone	.03	.03										.198	
638		167.5-169.2	shale	.01	.01										.300	
639		169.2-170.4	sandstone	.03	.03										.243	
640		170.4-174.3	shale	.03	.03										.226	
641		174.3-182.4	sandstone	.02	.02										.251	
642	DH-1	182.4-198.3	sandstone	.50	.49										.102	
643	DH-2	24.1-29.9	shale	.02	.02										.339	
644		30.9-31.5	shale	.14	.12										.396	
645		31.5-47.3	sandstone	.05	.09										.198	
646		47.3-52.6	shale	.16	.16	29	5	1.80		24.00					.420	
647		52.6-74.8	sandstone	.23	.23										.123	
648		74.8-75.5	shale	.01	.02										.139	
649		75.5-86.8	sandstone	.07	.07										.161	
650		87.3-99	shale	.02	.03										.236	
651		99-106.4	sandstone	.24	.22										.107	
652		107.5-114.3	shale	.02	.01										.181	
653		114.3-116.2	sandstone	.04	.07										.180	

Table 4
Sheet 2 of 7

SOILS LABORATORY REPORT

BUREAU OF RECLAMATION
SALT LAKE CITY, UTAH

Collom Gulch, Colo.
EMRIS Coal Study

LAB. No.	Boring Number	Depth In Feet	Field Text.	Hyd. Cond. 6 Hr. in/hr	Hyd. Cond. 24 Hr. in/hr	Tension in Bars 1/3 % Moisture	Tension in Bars 15 % Moisture	Saturation Extract ECe at 25°C.	Na. meq/l	Ca. Mg meq/l	K. meq/l	Mg meq/l	SAR True	SAR Ext.	1:5 ECs at 25°C	1:5 pH at 25°C
654	DH-2	116.2-119.7	shale	.05	.03										.227	
655		119.7-122.6	sandstone	.05	.07										.165	
656		122.6-123.8	shale	.08	.10			1.85	2.40	22.6			.7		.446	
657		123.8-126.7	sandstone	.06	.08										.193	
658		126.7-134.3	shale	.03	.03										.237	
659		134.3-141.6	sandstone	.03	.03										.214	
660		142.7-143.8	sandstone	.05	.06										.080	
661		143.8-144.1	shale	.03	.01										.091	
662		145-146.2	shale	.05	.04										.173	
663		146.2-151.1	sandstone	.05	.07										.190	
664	DH-2	151.1-153.6	shale	.05	.05										.204	
665	DH-1	198.7-205.1	sandstone	.08	.07										.159	
666		205.1-208.1	shale	.07	.07										.231	
667		208.1-221.8	sandstone	.07	.07										.178	
668		225.1-227.7	shale	.03	.03										.230	
669		227.7-235.8	sandstone	.04	.04										.232	
670		235.8-240.0	siltstone	.09	.09										.221	
671		243.2-246.6	sandstone	.09	.09										.199	
672		246.6-251.1	shale	.09	.07										.274	7.5
673		251.1-273.1	sandstone	.36	.32										.143	8.7
674		275.3-288.2	sandstone	.19	.18										.120	7.8
675		288.8-292.4	shale	.05	.05										.200	7.1
676		292.4-294.3	siltstone	.09	.09										.209	8.0
677		294.3-302	shale	.07	.06										.208	7.5
678		302-306.6	sandstone	.08	.10										.146	8.8
679	DH-1	306.6-311.2	shale	.05	.03										.243	8.0
680	DH-2	153.6-155.2	sandstone	.03	.03										.214	8.5
681	DH-2	155.2-157	shale	.08	.08										.249	8.5
682		157-164.5	siltstone	.06	.06										.252	8.5
683		164.5-168.2	shale	.05	.05										.235	7.4
684		168.2-170.7	sandstone	.08	.08										.243	8.4
685		170.7-177.1	shale	.05	.04										.270	8.1
686		177.1-179.4	siltstone	.02	.02										.184	8.3
687		179.4-180.3	shale	.07	.09	23	10	3.46	3.40	49.80				.68	.522	7.2
688		180.3-183.1	sandstone	.14	.14										.159	8.5
689		183.1-184.2	siltstone	.10	.10										.208	8.5
690		184.2-185.1	shale	.02	.03										.242	8.3
691		186.9-187.8	shale	.03	.02										.174	7.4
692		187.8-205.3	sandstone	.29	.27										.153	8.9
693		205.3-215.1	shale	.09	.09										.195	8.9
694		215.1-217.3	sandstone	.06	.06										.142	8.0
695		217.3-218.2	shale	.02	.02										.221	7.5
696		218.2-219.7	sandstone	.09	.09										.180	8.5
697		219.7-224.9	siltstone	.04	.04										.204	8.3
698		224.9-228	shale	.03	.03										.237	8.2
699		233.4-246.9	sandstone	.11	.12										.219	8.6
700		247.7-257.5	sandstone	.13	.15										.181	8.4
701		257.5-263.4	siltstone	.10	.09										.377	7.6
702		264.5-265.1	shale	.08	.07										.111	7.2
703		266.7-268.5	shale	.08	.06										.127	7.0
704		268.9-276.9	sandstone	.05	.05										.184	8.2
705		278.8-282.9	siltstone	.04	.05										.135	8.0
706		282.9-287.4	shale	.04	.04										.292	7.8
707		287.4-296.9	sandstone	.08	.10										.174	8.5

Table 4
Sheet 3 of 7

SOILS LABORATORY REPORT

BUREAU OF RECLAMATION
SALT LAKE CITY, UTAH

Collom Gulch, Colo.
EMRIA Coal Study

LAB. No.	Boring Number	Depth in Feet	Field Text.	Hyd. Cond. 6 Hr. in/hr	Hyd. Cond. 24 Hr. in/hr	Tension in Bars 1/3 % Moisture	Tension in Bars 15 % Moisture	Saturation Extract ECe at 25°C.	Na. meq/l	Ca. Mg meq/l	K. meq/l	Mg meq/l	SAR True	SAR Ext.	1:5 EC5 at 25°C	pH at 25°C
708	DH-2	296.9-300.4	siltstone	.23	.29										.348	7.8
709		301.8-305.7	shale	.04	.03										.160	8.0
710		305.7-311.5	siltstone	.07	.06										.253	8.2
711		311.5-321.8	sandstone	.08	.10										.174	8.6
712		321.8-326.9	shale	.05	.03										.320	8.0
713	DH-3	18-22.5	shale	.04	.04										.094	8.2
714		22.5-27.6	sandstone	.38	.36										.117	8.8
715		27.6-41	shale	.05	.06										.320	8.4
716		41-46.8	sandstone	.06	.08										.135	8.8
717		48.7-59.5	shale	.09	.09										.335	8.3
718		59.5-62.2	sandstone	.10	.11										.178	8.7
719		62.2-76.4	siltstone	.12	.12										.333	8.3
720		76.4-78.6	shale	.16	.14										.323	7.9
721		79.4-82.8	sandstone	.39	.41										.132	8.7
722		87-92.5	sandstone	.42	.44										.137	9.1
723		93.8-106.3	sandstone	.24	.28										.200	8.5
724		106.3-116.2	siltstone	.05	.07										.197	8.7
725		116.2-118.7	sandstone	.07	.09										.154	8.9
726		118.7-120.8	shale	.11	.11	21	9								.263	8.1
727		126.1-130.4	siltstone	.01	.02	22	9								.242	8.1
728		131.3-136.7	siltstone	0	0	18	8	2.65	19.9	1.43	.51	1.17		17.5	.303	8.5
729		136.7-142	sandstone	0	0	19	8	1.82	18.4	.66	.42	.36		25.9	.149	9.2
730		142-151.5	siltstone	0	0	21	10	3.40	32.4	2.75	.75	1.62		21.9	.309	9.1
731		151.5-153.4	sandstone	.06	.06	11	2								.292	8.9
732		153.4-155.8	shale	0	0	25	13	4.85	49.3	4.35	.77	1.89		27.9	.486	8.7
733		155.8-158.7	siltstone	0	0			3.53	35.8	1.27	.62	.72		35.8	.371	9.4
734		158.7-161.3	sandstone	.08	.08										.249	9.1
735		161.3-165.8	siltstone	0	0			3.50	38.3	1.16	.58	.72		39.6	.425	9.1
736		169-177.5	sandstone	0	0			2.90	32.4	.66	.53	.72		39.0	.319	9.4
737		177.5-183.9	siltstone and shale	0	0			4.06	44.0	1.1	.50	.54		49.4	.523	9.1
738		183.9-186.5	sandstone	0	0										.475	9.1
739		186.5-189	siltstone	0	0			4.46	47.2	.77	.59	.72		54.2	.537	9.3
740		189-191.7	sandstone	.03	.03											9.6
741	DH-3	191.7-194.1	siltstone	0	0			3.09	32.7	.61	.37	.27		49.5	.340	9.3
742		194.1-195.6	shale	0	0			3.18	34.0	.55	.34	.27		52.5	.329	8.4
743		197.4-200.6	sandstone	0	0			6.09	59.0	4.02	.84	1.80		34.7	.577	8.0
744		202.4-210.8	siltstone	0	0			3.43	35.4	1.21	.54	.72		36.1	.355	9.3
745		210.8-231.4	sandstone	.35	.41										.304	8.7
746		231.4-233.7	siltstone	0	0			4.11	43.6	3.19	.72	1.26		29.3	.430	9.2
747		235.6-245.5	siltstone	0	0										.353	8.7
748		248-259.7	siltstone and shale	0	0			2.84	33.4	1.32	.55	.54		34.8	.378	9.3
749		261.9-283.9	sandstone	.03	.03										.261	9.0
750		295.4-298.3	siltstone	.06	.08										.104	7.4
751	DH-3	298.3-306.6	sandstone	.31	.30										.152	8.5
752	DH-4	14.5-40.1	sandstone	.30	.27										.078	9.3
753		40.1-42.4	sandstone	.06	.06										.060	7.6
754		42.4-45.7	shale	.11	.10										.276	7.3
755		47.8-49.3	shale	.05	.05										.155	7.4
756		49.3-71.2	sandstone	.31	.29										.117	8.8
757		71.2-73.5	shale	.08	.07										.351	7.7
758		76.6-81.3	shale	.16	.16										.249	7.2
759		81.3-89.3	sandstone	.04	.04										.276	7.4
760		89.3-92.0	shale	.07	.05										.312	7.2
761		92-94.2	sandstone	.19	.21										.195	9.0

Table 4
Sheet 4 of 7

SOILS LABORATORY REPORT

BUREAU OF RECLAMATION
SALT LAKE CITY, UTAH

Collom Gulch, Colo.
EMRIA Coal Study

LAB. No.	Boring Number	Depth in Feet	Field Text.	Hyd. Cond. 6 Hr. in/hr	Hyd. Cond. 24 Hr. in/hr	Tension in Bars 1/3 % Moisture	Tension in Bars 15 % Moisture	Saturation Extract ECe at 25°C.	Na. meq/l	Ca. Mg meq/l	K. meq/l	Mg meq/l	SAR True	SAR Ext.	1:5 EC at 25°C	1:5 pH at 25°C
762		94.2-98	shale	.05	.05										.271	8.5
763		98-101	sandstone	.03	.03										.205	8.8
764		101-108	siltstone	.05	.05										.264	8.5
765		108-108.5	shale	.07	.07										.372	7.6
766		110.7-116.6	shale	.07	.07										.125	7.5
767		116.6-130.4	sandstone	.13	.13										.203	8.8
768		130.4-136.9	shale	.12	.13										.352	7.8
769	DH-4	136.9-142.7	siltstone	.03	.03										.251	8.3
770		142.7-146.2	sandstone	.14	.14										.209	8.8
771		146.2-149	shale	.21	.23										.340	8.2
772		153.4-154.5	shale	.18	.16										.171	8.0
773		154.5-158	sandstone	.09	.07										.295	7.8
774		158-160.3	siltstone	.09	.09										.196	6.6
775		160.3-161	coal and shale	1.19	3.24										.911	8.5
776		161-163.6	siltstone	.17	.16										.251	8.0
777		163.6-166.6	sandstone	.10	.12										.320	8.1
778		166.6-167	shale	.11	.09										.399	8.2
779		168.1-169.9	siltstone	.03	.03										.193	7.4
780		169.9-173.8	sandstone	.10	.10										.188	8.7
781		173.8-175	siltstone	.20	.18										.376	7.5
782		175-178.3	shale	.14	.16										.507	7.1
783		178.3-182	sandstone	.10	.12										.98	8.3
784		183.6-187.9	shale	.12	.10										.256	7.8
785		188.9-191.4	shale	.12	.12										.144	7.5
786		193.1-193.4	shale	.09	.08										.343	6.7
787	DH-4	193.4-206.6	sandstone	.23	.21										.113	8.5
788	DH-5	14.5-22.1	shale	.03	.04										.230	8.6
789		22.1-35.6	sandstone	.15	.15										.114	8.8
790		35.6-37.2	shale	.05	.07										.187	8.6
791		39.4-56.5	shale	.14	.13										.255	6.5
792		56.5-60.3	sandstone	.03	.03										.314	7.9
793		60.3-61.8	shale	.25	.25										.157	9.0
794		61.8-62.5	sandstone	.26	.26										.170	9.0
795		62.5-63.4	siltstone	.14	.14										.359	7.7
796		63.4-67.8	sandstone	.03	.03										.271	8.3
797	DH-5	67.8-71.5	shale	.31	.38										.287	6.9
798		71.5-73.6	siltstone	.15	.14										.257	8.0
799		73.6-86.7	sandstone	.09	.09										.166	8.7
800		86.7-88.4	shale and coal	.02	.03										.275	7.2
801		88.4-89.9	sandstone	.09	.09										.162	8.6
802		89.9-92.6	shale	.04	.04										.314	8.0
803		92.6-96.8	sandstone	.07	.09										.159	8.5
804		104.6-107.5	siltstone	.03	.05										.168	7.4
805		107.5-109.6	sandstone	.11	.13										.179	8.1
806		115.1-117.1	sandstone	.10	.09										.092	7.5
807		117.1-123.6	siltstone	.02	.03										.170	7.9
808		123.6-147.2	sandstone	.11	.11										.256	8.0
809		151.6-153.3	shale	.17	.21										.375	7.4
810		153.3-156.8	sandstone	.09	.09										.173	7.4
811		156.8-157.5	shale	.25	.25										.325	7.4
812		161.5-172.1	sandstone	.09	.09										.154	7.7
813		172.1-173.2	siltstone	.17	.21										.223	8.1
814		175.2-177.5	shale	.21	.24										.267	6.6
815		177.5-194.1	sandstone	.22	.25										.135	8.6
816		194.1-195.6	siltstone	.10	.10										.285	8.1

Table 4
Sheet 5 of 7

SOILS LABORATORY REPORT

BUREAU OF RECLAMATION
SALT LAKE CITY, UTAH

Collom Gulch, Colo.
EMRIA Coal Study

LAB. No.	Boring Number	Depth in Feet	Field Text.	Hyd. Cond. 6 Hr. in/hr	Hyd. Cond. 24 Hr. in/hr	Tension in Bars 1/3 % Moisture	Tension in Bars 15 % Moisture	Saturation Extract ECe at 25°C.	Na. meq/l	Ca. Mg meq/l	K. meq/l	Mg meq/l	SAR True	SAR Ext.	1:5 EC5 at 25°C	pH at 25°C
817		199.7-208.1	shale	.03	.03										.080	7.5
818		208.1-224.6	sandstone	.10	.10										.130	7.6
819		224.6-228.7	siltstone	.12	.11										.119	7.4
820		249.1-258.2	siltstone	.10	.09										.390	6.3
821		258.2-285.7	sandstone	.64	.64										.303	7.0
822		291.9-296.4	sandstone	.13	.14										.178	8.2
823		296.4-303.1	siltstone	.12	.10										.265	8.1
824		303.1-306.6	sandstone	.07	.07										.201	8.8
825	USGS #1	0-1	clay	.13	.09										.147	7.8
826		1-6	clay	.10	.09										.159	8.4
827		6-10	clay	.05	.05										.167	8.6
828		10-16	clay	.07	.07										.165	8.3
829		16-20	clay & sandstone	.07	.07										.169	8.3
830	USGS #1	20-21	clay	.05	.07										.209	8.4
831	USGS #2	0-1	clay	.56	.31										1.91	8.1
832		1-5	clay	.16	.14			1.03	1.67	5.94	1.68	2.52		.8	.426	8.2
833		5-6	silty clay	.09	.07										.223	8.2
834		6-9	silty clay	.14	.14										.230	8.4
835		9-17	silty clay	.07	.06										.233	8.2
836		17-20	silty clay	.04	.04										.379	8.2
837	USGS #2	20-22	silty clay	.10	.07										.128	8.1
838	USGS #3	0-4	clay loam	.52	.61										.112	8.4
839		4-11	sandy clay	.10	.07										.121	8.6
840		11-13	clay	.05	.07										.108	8.4
841		14-17	clayey gravel	.09	.09										.103	8.4
842		17-20	clay	.10	.14										.128	8.3
843	USGS #3	20-22	gravely clay	.14	.14										.130	8.3
844	AH-2	0-0.5	loam	.61	.73										.069	7.8
845		0.5-2	clay	.27	.34				1.48	3.30	.09	3.34		.8	.667	8.1
846		2-4	shale	.10	.09										1.72	8.5
847		4-5	shale	.04	.04				29.7	27.5	.45	75.7		4.1	1.99	8.2
848		5-6	shale	.25	.29				33.5	24.8	.45	92.9		4.4	2.00	8.5
849		6-7.5	shale	.17	.17				30.1	13.8	.37	64.9		4.8	1.26	8.6
850		7.5-9.5	shale	.15	.13				25.3	14.3	.34	55.		4.3	.610	8.6
851	AH-2	9.5-10.5	shale	.04	.04				19.2	6.8	.37	27.8		4.6	.590	8.5
852	AH-3	0-2	clay	.04	.02										.144	8.1
853	AH-3	2-3	shale	.25	.23										1.32	8.3
854		3-4	shale	.27	.32										1.35	8.2
855		4-6	weathered sandstone	.20	.24										.071	8.9
856		6-7.8	shale	.26	.28										.222	9.3
857	AH-6	0-0.5	loam	.28	.21										.091	7.3
858		0.5-1	clay loam	.63	.54										.100	7.2
859		1-2	shale	.05	.07										.208	8.3
860		2-3	shale	.32	.26										.359	8.5
861		3-6	shale	.28	.21				12	27.4	.17	15.9		2.6	.888	8.2
862		6-8	shale	.09	.07	24	11								.399	8.5
863		8-9	sandstone	.10	.09	20	8								.348	8.4
864	AH-7	0-1	clay loam	.48	.44	22	9								.189	7.5
865		1-4		.19	.17	25	16								.212	8.3
866	AH-8	0-1	clay loam	.87	.89	9	8								.121	7.6
867		1-5	sandstone	.19	.17	19	7								.096	8.8
868		5-6	shale	.20	.17	27	16								.195	8.1
869		6-14	coal	.31	.26	32	25	1.78	4.43	7.5	.16	9.26		1.5	.407	5.2
870		14-14.5	shale	.14	.09	30	16								.182	5.8

SOILS LABORATORY REPORT

BUREAU OF RECLAMATION
SALT LAKE CITY, UTAH

Collom Gulch, Colo.
EMRIA Coal Study

LAB. No.	Boring Number	Depth in Feet	Field Text.	Hyd. Cond. 6 Hr. in/hr	Hyd. Cond. 24 Hr. in/hr	Tension in Bars 1/3 % Moisture	Tension in Bars 15 % Moisture	Saturation Extract ECe at 25°C.	Na. meq/l	Ca. Mg meq/l	K. meq/l	Mg meq/l	SAR True	SAR Ext.	1:5 EC at 25°C	pH at 25°C
871	AH-9	0-1	clay	.72	.57	24	11								.119	8.4
872		1-2	clay	.42	.35	25	13								.121	8.3
873		2-3	clay	.47	.43	27	5								.135	8.4
874		3-5	silty clay loam	.32	.30	20	12								.185	8.7
875		5-8	silty clay loam	.65	.62	28	11	4.34	27.7	12.7	.08	13.3		7.7	.636	8.4
876		8-13	shale	.05	.04	31	19	3.95	19.2	18.6	.08	16.3		4.6	.722	8.3
877		13-14	shale	.11	.07	27	16								.399	8.3
878	AH-11	0-1	clay	1.32	1.62	27	18								.138	7.8
879		1-4	shale	.27	.31	29	20	6.84	23	25.3	.06	52.3		3.7	2.72	8.3
880		4-7	shale	.10	.09	27	19	7.50	34.4	20.4	.11	67.6		5.2	1.34	8.7
881	AH-11	7-8	black shale	.07	.05	49	27	5.87	28.2	11.4	.16	36.6		5.8	1.22	8.2
882		8-9	shale	.02	.02	26	18	3.90	18.1	7.3	.15	21.7		4.8	.676	8.6
883	AH-13	0-1	clay	.66	.75	29	15								.130	8.5
884		1-4	shale	.26	.24	31	19								.259	8.9
885		4-5	shale	.02	.02	31	19	3.80	16.0	5.6	.13	30.8		3.7	.886	9.1
886		5-11	shale	.09	.07	30	21								.272	9.3
887		11-11.5	mudstone	.07	.05	25	19								.197	9.3
888	AH-15	0-1	silty clay loam	.15	.12	26	13								.106	7.2
889		1-3	clay	.05	.05	26	16								.098	7.5
890		3-5	shale	.05	.05	26	19		17.5	8.9	.04	8.44		6.0	.490	8.5
891		5-9	shale	.32	.30	26	9		24.4	29.7	.03	24.3		4.7	.965	8.2
892		9-9.5	sandstone	.15	.17	21	13								.686	8.3
893	AH-16	0-1	loam	1.68	2.42	23	14								.085	6.9
894		1-2	clay	.39	.41	21	12								.032	7.4
895		2-4	shale	.02	.02	32	20								.271	8.6
896		4-5	shale	.03	.03	28	21		26	24.1	.20	32.8		4.9	3.09	8.3
897		5-6	shale	.18	.16	22	13		24.4	27.6	.15	31.9		4.4	1.04	8.6
898		6-7.5	weathered sandstone	.45	.47	17	7		22.3	26.3	.17	33.5		4.1	.706	8.7
899	AH-18	0-1	clay loam	.40	.31	26	13								.164	7.8
900		1-2	clay	.26	.27	29	18								.143	8.6
901		2-3	shale	.40	.46	35	19								.164	8.7
902		3-6	shale	.22	.26	35	18								.335	8.9
903		6-9	shale	.03	.02	29	19		15.7	13.2	.10	14.3		4.2	.640	8.7
904		9-10	siltstone	.05	.05	22	10								.068	8.8
905	AH-20	0-1	clay	.17	.12	23	11								.281	8.1
906		1-2	clay	.05	.07	26	13								.109	7.9
907		2-5	shale	.07	.07	26	15								.195	8.8
908		5-8	shale	.03	.05	22	12								.160	9.2
909	AH-20	8-9	siltstone	.07	.05	20	7								.144	9.1
910	AH-21	0-1	clay	.13	.10	28	13								.112	7.7
911		1-3	clay	.20	.24	30	16								.160	8.6
912		3-5	shale	.05	.05	25	16	3.51	6.7	23.5	.08	21.9		1.4	.665	8.6
913		5-7	siltstone	.07	.07	19	8								.168	7.0
914	Hand Aug #1	0-1	sandy clay loam	.55	.60	18	8								.087	7.6
915		1-2	sandy clay	.28	.27	23	10								.055	7.5
916	HA #2	0-1.8	loam	1.74	2.35	23	13								.089	7.7
917	HA #5	0-0.7	loam	.94	1.29	19	8								.078	7.9
918		0.7-1.3	clay loam	.41	.39	19	9								.072	7.8
919		1.3-4.2	clay	.07	.07	27	13								.074	7.9
920		4.2-5	shale	.14	.14	28	14								.172	8.9
921	#3 Sec 3	0.3-1.2	clay	.03	.05	36	21								.200	8.5
922		1.2-4	shale	.32	.31	27	15								.584	8.8
923	#3 sec 10	0-2	loam	1.04	1.23	25	13								.109	7.4
924		2-2.5	fine sandy loam	.26	.24	20	7								.070	7.4

Table 4
Sheet 7 of 7

SOILS LABORATORY REPORT

BUREAU OF RECLAMATION
SALT LAKE CITY, UTAH

Collom Gulch, Colo.
EMRIA Coal Study

LAB. No.	Boring Number	Depth in Feet	Field Text.	Hyd. Cond. 6 Hr. in/hr	Hyd. Cond. 24 Hr. in/hr	Tension in Bars 1/3 % Moisture	Tension in Bars 15 % Moisture	Saturation Extract ECe at 25°C.	Na. meq/l	Ca. Mg meq/l	K. meq/l	Mg meq/l	SAR True	SAR Ext.	1:5 EC at 25°C	pH at 25°C
925	#5 Sec 4	0-1	loam	.79	.86	19	8								.065	7.0
926	#5 Sec 4	1-2.3	clay loam	.22	.24	20	9								.043	7.2
927		2.3-3	shale	.15	.17	24	7								.052	7.6
928	#3 Sec 32	0-1	clay	.10	.10	23	8								.085	7.1
929		1-3	shale	.03	.03	29	19	2.37	4.35	8.7	.21	19.3		1.2	.400	8.5
930	#8	0-1.5	clay	.09	.07	29	17								.071	7.4
931	#2 Sec 10	0-0.7	loam	.26	.24	21	9								.136	7.3
932	A	0-1	clay loam	.12	.12	29	15								.102	7.3
933		1-2.5	clay	.06	.06	32	17								.146	7.4
934		2.5-4	clay	.22	.27	28	13								.183	7.9
935		4-5	clay	.24	.28	29	14								.205	8.3
936	#22	0-0.5	loam	.21	.23	20	8								.092	8.0
937	#22	0.5-1.7	clay	.03	.03	33	19								.126	7.9
938		1.7-2	clay	.10	.13	24	13								.158	8.5
939		2-2.5	loam & sandstone	.21	.26	17	6								.155	8.8
940	#24	0-1.2	clay loam	.30	.33	29	17								.174	8.3
941		1.2-2	clay	.16	.21	29	16								.183	8.2
942		2-3.8	shale	.17	.26	28	15								.177	8.2
943	#11	0-1	clay	.20	.14	32	18								.146	7.8
944		1-2.3	clay	.17	.26	31	17								.084	7.9
934		2.3-3	light clay	.18	.26	27	14								.177	7.8
946	Bottomlands Control	0-0.3	clay loam	.69	.84	32	17								.193	7.9

Table 5
Land classification tabulation

Section	Class 1	Class 2	Class 3	Suitable subtotal	Class 6	Total acres classified
NE		38.9		38.9	125.03	163.93
3 NW		27.8		27.8	135.51	163.31
SW		50.0		50.0	110.00	160.00
SE		2.8	22.7	25.5	134.50	160.00
Subtotal		119.5	22.7	142.2	505.04	647.24
NE		84.2	33.0	117.2	45.51	162.71
4 NW		15.0	12.8	27.8	134.33	162.13
SW		28.1	3.2	31.3	128.70	160.00
SE		76.1	11.7	87.8	72.20	160.00
Subtotal		203.4	60.7	264.1	380.74	644.84
NE		73.8	18.5	92.3	69.36	161.66
5 NW	27.6	13.5	14.4	55.5	105.80	161.30
SW	8.8	30.0	17.1	55.9	104.10	160.00
SE		12.7	50.4	63.1	96.90	160.00
Subtotal	36.4	130.0	100.4	266.8	376.16	642.96
NE		7.1	29.1	36.2	123.80	160.00
8 NW		7.6	67.7	75.3	84.70	160.00
Subtotal		14.7	96.8	111.5	208.50	320.00
NE		20.1	41.5	61.6	98.40	160.00
9 NW		17.5	27.8	45.3	114.70	160.00
Subtotal		37.6	69.3	106.9	213.10	320.00
NE			17.8	17.8	142.20	160.00
10 NW		7.9	22.1	30.0	130.00	160.00
Subtotal		7.9	39.9	47.8	272.20	320.00
NE	6.5	103.0	10.8	120.3	39.70	160.00
27 NW		22.1	20.9	43.0	107.90	150.90
SW		43.0	20.9	63.9	96.14	160.04
SE		136.1		136.1	23.90	160.00
Subtotal	6.5	304.2	52.6	363.3	267.64	630.94
NE	16.0	36.6	28.2	80.8	55.30	136.10
32 NW		71.5	61.9	133.4	26.88	160.28
SW	11.8		54.6	66.4	93.60	160.00
SE	4.3	88.1	28.2	120.6	39.40	160.00
Subtotal	32.1	196.2	172.9	401.2	215.18	616.38
NE		19.8	40.6	60.4	99.60	160.00
33 NW		56.4	56.3	112.7	38.60	151.30
SW		15.3	19.0	34.3	125.70	160.00
SE		52.0	51.6	103.6	56.40	160.00
Subtotal		143.5	167.5	311.0	320.30	631.30
NE		60.2		60.2	99.80	160.00
34 NW		83.8	37.9	121.7	38.30	160.00
SW		121.5	28.9	150.4	9.60	160.00
SE		4.9		4.9	155.10	160.00
Subtotal		270.4	66.8	337.2	302.80	640.00
Grand total	75.0	1,427.4	849.6	2,352.0	3,061.66	5,413.66

7-1337 (8-74)
Bureau of Reclamation

GEOLOGIC LOG OF DRILL HOLE

TABLE 6 SHEET 1 OF 3

FEATURE Collom Gulch Study Site PROJECT Emria Coal Study STATE Colorado
HOLE NO. DH-1 LOCATION SW¼ NW¼, SEC. 32, T.4 N., R. 94W. GROUND ELEV. 7440± 1/ DIP (ANGLE FROM HORIZ.) 90.0 degrees Down
COORDS. N. E.
BEGUN 08-25-80 FINISHED 09-12-80 DEPTH OF OVERBURDEN 3.5 feet TOTAL DEPTH 311.2 feet BEARING
DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED 187.0 feet 09-11-80 2/ LOGGED BY D. Grundvig LOG REVIEWED BY F. Thompson

Driller: J. Dunn, B.O.R.

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS

NOTE: 1/
All measurements are from ground surface. Hole was not surveyed, deviation (if any) from vertical is unknown.

PURPOSE OF HOLE:
To obtain samples for determination of overburden properties.

DRILLING EQUIPMENT:
Skid-mounted Sprague and Henwood.

DRILLING FLUID:
water, recirculated.

DRILLING FLUID LOSSES:
No water losses reported from 0.0 to 75.1'. 25 to 100% losses for the remainder of the hole.

CASING RECORD:

Cs Size (in.)	Depth of Cs (feet)	Hole Depth (feet)
-	-	10.1
4	10.1	10.1-311.2

HOLE COMPLETION:
Geophysical logs were run in hole by U.S.G.S.
Well points were installed with tips at 135.0' and 224.8' (3' influence zones) for ground water studies.
No unusual drilling conditions, other than loss of drill water, were reported by driller.
2/Water level measurement on last day of drilling, probably does not represent water table.

TYPE AND SIZE OF HOLE: HQ Wire-line ($3\frac{1}{2}$") (0–100)

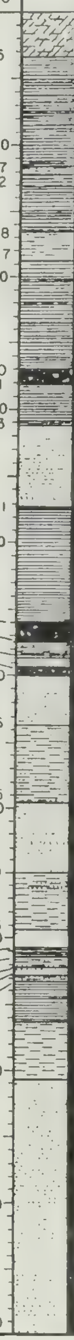
CORE RECOVERY (%) by run: 0, 88, 92, 82, 93, 87, 100, 92, 100, 95, 95

SUITABILITY OF OVERBURDEN

Interval (feet)	Suitable	Limited Suitability	Unsuitable
0.0–18.7	+		
18.7–27.0		+	
27.0–28.1			COAL
28.1–46.0		+	
46.0–47.5			COAL
47.5–48.6		+	
48.6–49.3			COAL
49.3–80.8		+	
80.8–100.0			+

ELEVATION (FEET)	DEPTH (FEET)
7440.0	0.0
7436.5	3.5
7428.3	11.7
7427.8	12.2
7423.2	16.8
7421.3	18.7
7413.0	27.0
7411.9	28.1
7408.7	31.3
7402.9	37.1
7394.0	46.0
7392.5	47.5
7391.4	48.6
7390.7	49.3
7386.4	53.6
7380.5	59.5
7375.0	65.0
7370.7	69.3
7369.2	70.8
7368.5	71.5
7367.9	72.1
7367.4	72.6
7366.7	73.3
7363.8	76.2
7359.2	80.8
7340.0	100.0

GRAPHIC LOG



SAMPLES FOR TESTING

CLASSIFICATION AND PHYSICAL CONDITION

0.0-3.5: Lean Clay: Approximately 70%, fines with medium plasticity, 30% fine sand, slight to moderate reaction with HCL, dark to light brown, dry. (CL)

3.5-311.2: Cretaceous Williams Fork Formation (Kw)
Interbedded sandstone, siltstone, shale, and coal. Individual units are described below.

Sandstone: principally quartzose but may be argillaceous in part, very fine to medium grained, subangular to subrounded grains, fresh to moderately weathered, weakly to well cemented, bedding indistinct, lightly jointed, black carbonaceous swirls and laminations in part, occassional slickensides, slight to moderate porosity, light gray to yellow brown, strong to no reaction with HCL. Core recovered in fragments to 3.3' lengths (most less than 1.5'). Most contacts are gradational.

Siltstone: carbonaceous and sandy in part, frequent shale partings, fresh to moderately weathered, moderately hard, moderately well cemented, indistinct bedding, lightly jointed, occasional near-vertical fractures and slickensides, gray to yellow brown, frequent leaf imprints, slight to strong reaction with HCL. Core recovered in 0.1' to 0.8' lengths. Most breaks are inclined approximately 10 degrees to the horizontal with rough, irregular surfaces. Most contacts are gradational.

Shale: carbonaceous and sandy in part, fresh to moderately weathered, slight to moderate air slaking, fissility poorly to moderately developed. Occasional slickensides, gray to black, slight to no reaction with HCL. Core recovered in fragments to 0.3' lengths. Most contacts are gradational.

EXPLANATION

CORE LOSS
CORE RECOVERY

Fe=oxides of iron, i.e. limonite and hematite
HCL=hydrochloric acid (10% solution)

Type of hole . . . D = Diamond, H = Haystellite, S = Shot, C = Churn
Hole sealed . . . P = Packer, Cm = Cemented, Cs = Bottom of casing
Approx. size of hole (X-series) . . Ex = 1-1/2", Ax = 1-7/8", Bx = 2-3/8", Nx = 3"
Approx. size of core (X-series) . . Ex = 7/8", Ax = 1-1/8", Bx = 1-5/8", Nx = 2-1/8"
Outside dia. of casing (X-series) . Ex = 1-13/16", Ax = 2-1/4", Bx = 2-7/8", Nx = 3-1/2"
Inside dia. of casing (X-series) . . Ex = 1-1/2", Ax = 1-29/32", Bx = 2-3/8", Nx = 3"

FEATURE Collom Gulch Study Site PROJECT Emria STATE Colorado SHEET 1 OF 3 HOLE NO. DH-1

☆GPO 679-482

7-1337 (8-74)
Bureau of Reclamation

GEOLOGIC LOG OF DRILL HOLE

FEATURE Collom Gulch Study Site PROJECT Emria Coal Study STATE Colorado

HOLE NO. DH-1 LOCATION SW¼, NW¼, SEC.32, T.4 N., R. 94W. GROUND ELEV. 7440± DIP (ANGLE FROM HORIZ.) 90.0 degrees Down

COORDS. N. E.

BEGUN 08-25-80 FINISHED 09-12-80 DEPTH OF OVERBURDEN 3.5' TOTAL DEPTH 311.2' BEARING

DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED 187.0' 09-11-80 2/ LOGGED BY D. Grundvig LOG REVIEWED BY F. Thompson

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS	TYPE AND SIZE OF HOLE	CORE RECOVERY (%)	SUITABILITY OF OVERBURDEN	ELEVATION (FEET)	DEPTH (FEET)
	HQ Wire-line (3½")	95	Unsuitable	7340.0	100.0
				7334.6	105.4
				7334.2	105.8
		96	Limited suitability	7330.1	109.9
	110				110
				7322.5	117.5
	120	100			120
	130	96			130
			COAL	7308.5	131.5
				7307.9	132.1
			Limited suitability	7305.1	134.9
	140	96			140
			COAL	7298.3	141.7
		100		7295.2	144.8
			Limited suitability	7293.0	147.0
				7291.3	148.7
	150			7289.3	150.7
		82		7288.1	151.9
				7287.3	152.7
		74		7281.9	158.1
	160			7279.8	160.2
		100		7272.5	167.5
				7270.8	169.2
	170	100		7269.6	170.4
				7265.7	174.3
	180	95			180
	190 HQ Wire-line (3½")	20			190
		50		7241.7	198.3
				7240.0	198.7
					200.0

CLASSIFICATION AND PHYSICAL CONDITION

Coal: dull to shiny black, mostly recovered in fragments less than 0.1'. Frequent, thin carbonaceous shale partings.

3.5 - 11.7: Shale
11.7 - 12.2: Siltstone; yellow brown, abundant Fe staining.
12.2 - 16.8: Shale
16.8 - 18.7: Siltstone
18.7 - 27.0: Shale
27.0 - 28.1: Coal
28.1 - 31.3: Shale
31.3 - 37.1: Sandstone; Fe-stained, near-vertical fracture at 33.3'.
37.1 - 46.0: Shale
46.0 - 47.5: Coal
47.5 - 48.6: Shale
48.6 - 49.3: Siltstone; slickenside inclined approximately 35 degrees to the horizontal at 49.2.
49.3 - 50.0: Coal
50.0 - 53.6: Sandstone
53.6 - 59.5: Siltstone
59.5 - 65.0: Sandstone
65.0 - 69.3: Siltstone
69.3 - 70.8: Sandstone
70.8 - 71.5: Shale
71.5 - 72.1: Siltstone
72.1 - 72.6: Sandstone
72.6 - 73.3: Siltstone
73.3 - 76.2: Shale
76.2 - 80.8: Siltstone
80.8 - 105.4: Sandstone
105.4 - 105.8: Shale
105.8 - 109.9: Sandstone; minor shale partings.
109.9 - 117.5: Siltstone
117.5 - 131.5: Sandstone; slickensides inclined 15 degrees to the horizontal, at 128.6' and 128.8'.
131.5 - 132.1: Coal
132.1 - 134.9: Sandstone
134.9 - 141.7: Siltstone
141.7 - 144.8: Coal
144.8 - 147.0: Siltstone
147.0 - 148.7: Shale; air slakes readily.
148.7 - 150.7: Sandstone
150.7 - 151.9: Shale
151.9 - 152.7: Siltstone
152.7 - 158.1: Sandstone
158.1 - 160.2: Shale
160.2 - 167.5: Sandstone; minor amounts of pyrite on some breaks.
167.5 - 169.2: Shale
169.2 - 170.4: Sandstone
170.4 - 174.3: Shale
174.3 - 198.3: Sandstone

EXPLANATION

CORE LOSS
CORE RECOVERY

Type of hole . . . D = Diamond, H = Haystellite, S = Shot, C = Churn
Hole sealed . . . P = Packer, Cm = Cemented, Cs = Bottom of casing
Approx. size of hole (X-series) . . Ex = 1-1/2", Ax = 1-7/8", Bx = 2-3/8", Nx = 3"
Approx. size of core (X-series) . . Ex = 7/8", Ax = 1-1/8", Bx = 1-5/8", Nx = 2-1/8"
Outside dia. of casing (X-series) . Ex = 1-13/16", Ax = 2-1/4", Bx = 2-7/8", Nx = 3-1/2"
Inside dia. of casing (X-series) . Ex = 1-1/2", Ax = 1-29/32", Bx = 2-3/8", Nx = 3"

GPO 679-482

7-1337 (6-74)
Bureau of Reclamation

GEOLOGIC LOG OF DRILL HOLE

TABLE 6 SHEET 3 OF 3

FEATURE Collom Gulch Study Site PROJECT Emria Coal Study STATE Colorado

HOLE NO. DH-1 LOCATION SW¼ NW¼, SEC.32, T.4N., R.94W. GROUND ELEV. 7440± DIP (ANGLE FROM HORIZ.) 90.0degrees.Down

COORDS. N. E.

BEGUN 08-25-80 FINISHED 09-12-80 DEPTH OF OVERBURDEN 3.5' TOTAL DEPTH 311.2' BEARING

DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED 187.0' 09-11-80 2/ LOGGED BY D. Grundvig LOG REVIEWED BY F. Thompson

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS	TYPE AND SIZE OF HOLE	CORE RECOVERY (%)	SUITABILITY OF OVERBURDEN: SUITABLE	LIMITED SUITABILITY	UNSUITABLE	ELEVATION (FEET)	DEPTH (FEET)
	HQ Wireline ($3\frac{1}{2}$")	68				7240.0	200.0
		100				7234.9	205.1
		100				7232.0	208.0
		89				7218.2	221.8
					COAL	7214.9	225.1
		100					227.7
						7204.2	235.8
		90				7200.0	240
					COAL	7196.8	243.2
		95				7193.4	246.6
		89				7188.9	251.1
		100					
		100			COAL	7166.9	273.1
						7164.7	275.3
		100			COAL	7151.8	288.2
	HQ Wireline ($3\frac{1}{2}$")	100				7151.2	288.8
		100				7147.6	292.4
	HQ Wireline ($3\frac{1}{2}$")	100				7145.7	294.3
		100				7140.0	300.0
						7138.0	302.0
						7133.4	306.6
						7128.8	311.2

TOTAL DEPTH 311.2'

GRAPHIC LOG — SAMPLES FOR TESTING

CLASSIFICATION AND PHYSICAL CONDITION

198.3 - 198.7: Coal; shale parting at 198.7.
198.7 - 205.1: Sandstone
205.1 - 208.0: Shale
208.0 - 221.8: Sandstone
221.8 - 225.1: Coal
225.1 - 227.7: Shale
227.7 - 235.8: Sandstone; high angle fracture from 230.7 to 231.5 - surface is rough, irregular and free of secondary mineralization.
235.8 - 240.0: Siltstone
240.0 - 243.2: Coal
243.2 - 246.6: Sandstone
246.6 - 251.1: Shale
251.1 - 273.1: Sandstone
273.1 - 275.3: Coal
275.3 - 288.2: Sandstone
288.2 - 288.8: Coal
288.8 - 292.4: Shale
292.4 - 294.3: Siltstone; slickensides inclined 45-60 degrees to the horizontal, at 289.1, 289.3, and 289.7. Near-vertical fracture with rough, irregular surface at 293.9'.
294.3 - 302.0: Shale
302.0 - 306.6: Sandstone
306.6 - 311.2: Shale

7 1337 (6-74)
Bureau of Reclamation

GEOLOGIC LOG OF DRILL HOLE

TABLE 6 SHEET 1 OF 4

FEATURE Collom Gulch Study Site PROJECT Emria Coal Study STATE Colorado

HOLE NO. DH-2 LOCATION NE¼ SE¼ SEC 32 T.4 N., R. 94W. GROUND ELEV. 7335' ± 1/ DIP (ANGLE FROM HORIZ.) 90.0 degrees Down

COORDS. N. E.

BEGUN 09-13-80 FINISHED 09-22-80 DEPTH OF OVERBURDEN 6.0' TOTAL DEPTH 326.9' BEARING

DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED Not Measured LOGGED BY D. Grundvig LOG REVIEWED BY F. Thompson

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS	TYPE AND SIZE OF HOLE	CORE RECOVERY (%)	SUITABILITY OF OVERBURDEN: SUITABLE	LIMITED SUITABILITY	UNSUITABLE	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	SAMPLES FOR TESTING	Driller: J. Dunn, B.O.R. CLASSIFICATION AND PHYSICAL CONDITION
						7335	0.0			

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS

NOTE: 1/
All measurements are from ground surface. Hole was not surveyed, deviation (if any) from vertical is unknown.

PURPOSE OF HOLE:
To obtain samples for determination of overburden properties.

DRILLING EQUIPMENT:
Skid-mounted Sprague and Henwood.

DRILLING FLUID:
Water, recirculated.

DRILLING FLUID LOSSES:
Driller reports no water losses from 0.0 to 58.0, 100% loss from 58.0 to 326.9.

CASING RECORD:

Cs Size (inch)	Depth of Cs (feet)	Hole Depth (feet)
-	-	24.1
4.0	20.0	24.1-31.1
4.0	30.0	31.1-326.9

HOLE COMPLETION:
Geophysical logs were run in hole by U.S.G.S.
Well points were installed with tips at 193.0' and 214.9'.
Length of influence zones not reported by driller.

No unusual drilling conditions were reported by driller.

TYPE AND SIZE OF HOLE: 4½" RB (0.0–24.1); HQ wire-line (3½") (from 24.1); HQ wire-line (3½") (from approx. 84)

CORE RECOVERY (%): 0; 100; 80; 90; 100; 100; 40; 0; 100; 60; 64

SUITABILITY OF OVERBURDEN: Suitable 0.0–6.0; Limited suitability 6.0–29.9; COAL (Unsuitable) 29.9–30.9; Limited suitability 30.9–86.8; COAL (Unsuitable) 86.8–87.3; Limited suitability 87.3–100.0

ELEVATION / DEPTH (FEET):

Elevation	Depth
7335	0.0
7329.0	6.0
7305.1	29.9
7304.1	30.9
7303.5	31.5
7287.7	47.3
7282.4	52.6
7260.2	74.8
7259.5	75.5
7248.2	86.8
7247.7	87.3
7236.0	99.0
7235.0	100.0

CLASSIFICATION AND PHYSICAL CONDITION

0.0 - 6.0: Lean Clay: Approximately 70% fines with medium plasticity, 30% fine sand, slight to moderate reaction with HCL, dark to light brown, dry. (CL)

6.0 - 326.9: Cretaceous Williams Fork Formation (Kw)
Interbedded sandstone, siltstone, shale and coal. Individual units are described below.

Sandstone: principally quartzose but may be argillaceous in part, very fine to medium grained, subangular to subrounded grains, fresh to moderately weathered (mostly fresh), weakly to well cemented (mostly moderately cemented), bedding indistinct, lightly jointed, frequent black, carbonaceous swirls and laminations, occasional slickensides, slight to moderate porosity, gray to tan, slight to strong reaction with HCL. Core recovered in 0.1' to 2.9' lengths (most less than 1.0'). Most contacts are gradational.

Siltstone: carbonaceous and sandy in part, frequent shale partings, fresh to lightly weathered (Fe staining restricted to some joints), moderately hard, moderately well cemented, no distinct bedding, occasional joint inclined 30 degrees to 45 degrees to the horizontal, occasional slickensides, light to dark gray, frequent leaf imprints, slight to strong reaction with HCL. Core recovered in 0.1' to 1.0' lengths. Most breaks are approximately horizontal but rough and irregular. Most contacts are gradational.

Shale: carbonaceous and sandy in part, fresh to lightly weathered (Fe staining restricted to some breakage planes), slight to moderate air slaking, moderately cemented, fissility poorly to moderately developed. Occasional slickensides, gray to black, slight to no reaction with HCL. Core recovered in fragments to 0.3' lengths. Most contacts are gradational.

EXPLANATION

CORE LOSS
CORE RECOVERY

RB = rock bit
Fe = oxides of iron, i.e. limonite and hematite
HCL = hydrochloric acid (10% solution)

Type of hole . . . D = Diamond, H = Haystellite, S = Shot, C = Churn
Hole sealed . . . P = Packer, Cm = Cemented, Cs = Bottom of casing
Approx. size of hole (X-series) . . Ex = 1-1/2", Ax = 1-7/8", Bx = 2-3/8", Nx = 3"
Approx. size of core (X-series) . . Ex = 7/8", Ax = 1-1/8", Bx = 1-5/8", Nx = 2-1/8"
Outside dia. of casing (X-series). Ex = 1-13/16", Ax = 2-1/4", Bx = 2-7/8", Nx = 3-1/2"
Inside dia. of casing (X-series) . Ex = 1-1/2", Ax = 1-29/32", Bx = 2-3/8", Nx = 3"

☆ GPO 679-482

GEOLOGIC LOG OF DRILL HOLE

FEATURE Collom Gulch Study Site PROJECT Emria Coal Study STATE Colorado
HOLE NO. DH-2 LOCATION NE¼ SE¼, SEC 32, T.4 N., R. 94W. GROUND ELEV. 7335' ± DIP (ANGLE FROM HORIZ.) 90.0 degrees Down
COORDS. N. E.
BEGUN 09-13-80 FINISHED 09-22-80 DEPTH OF OVERBURDEN 6.0' TOTAL DEPTH 326.9' BEARING
DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED Not Measured LOGGED BY D. Grundvig LOG REVIEWED BY F. Thompson

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS | TYPE AND SIZE OF HOLE | CORE RECOVERY (%) | SUITABILITY OF OVERBURDEN: SUITABLE / LIMITED SUITABILITY / UNSUITABLE | ELEVATION (FEET) | DEPTH (FEET) | GRAPHIC LOG | SAMPLES FOR TESTING | CLASSIFICATION AND PHYSICAL CONDITION

Type and size of hole: HQ wire-line (3½"); HQ wire-line

Core recovery (%): 64; 100; 94

Unsuitable: COAL; COAL; COAL; COAL

Elevation (feet)	Depth (feet)
7235.0	100.0
7228.6	106.4
7227.5	107.5
7220.7	114.3
7218.8	116.2
7215.3	119.7
7212.4	122.6
7211.2	123.8
7208.3	126.7
7200.7	134.3
7193.4	141.6
7192.3	142.7
7191.2	143.8
7190.9	144.1
7190.0	145.0
7188.8	146.2
7183.9	151.1
7181.4	153.6
7179.8	155.2
7178.0	157.0
7170.5	164.5
7166.8	168.2
7164.3	170.7
7157.9	177.1
7155.6	179.4
7154.7	180.3
7151.9	183.1
7150.8	184.2
7149.9	185.1
7148.1	186.9
7147.2	187.8
7135.0	200.0

Driller: J. Dunn, B.O.R.

Coal: Dull to shiny black, mostly recovered in fragments less than 0.1'. Frequent thin carbonaceous shale partings.
6.0 - 29.9: Shale, considerable weathering in upper part.
29.9 - 30.9: Coal
30.9 - 31.5: Shale, black, carbonaceous
31.5 - 47.3: Sandstone, Intense Fe staining at 36.4.
47.3 - 52.6: Shale, occasional streak of coal.
52.6 - 74.8: Sandstone, tan.
74.8 - 75.5: Shale, carbonaceous.
75.5 - 86.8: Sandstone, small shale and siltstone lenses (less than 0.3' thick), carbonaceous in part.
86.8 - 87.3: Coal
87.3 - 99.0: Shale, frequent slickensides.
99.0 - 106.4: Sandstone, abrupt contact with coal below.
106.4 - 107.5: Coal
107.5 - 114.3: Shale, minor sandstone lenses to 0.3' thick.
114.3 - 116.2: Sandstone, minor shale partings.
116.2 - 119.7: Shale
119.7 - 122.6: Sandstone
122.6 - 123.8: Shale, 0.1' thick coal seam at 123.3.
123.8 - 126.7: Sandstone
126.7 - 134.3: Shale, occasional sandstone lenses.
134.3 - 141.6: Sandstone, minor shale lenses, carbonaceous in part.
141.6 - 142.7: Coal
142.7 - 143.8: Sandstone
143.8 - 144.1: Shale
144.1 - 145.0: Coal
145.0 - 146.2: Shale
146.2 - 151.1: Sandstone, shale parting at 147.4 and 148.3. Near vertical fracture 149.6 to 151.0.
151.1 - 153.6: Shale
153.6 - 155.2: Sandstone, carbonaceous in upper part.
155.2 - 157.0: Shale, air slakes badly.
157.0 - 164.5: Siltstone, carbonaceous, frequent leaf imprints.
164.5 - 168.2: Shale
168.2 - 170.7: Sandstone
170.7 - 177.1: Shale, with minor sandstone lenses.
177.1 - 179.4: Siltstone
179.4 - 180.3: Shale
180.3 - 183.1: Sandstone
183.1 - 184.2: Siltstone

EXPLANATION

CORE LOSS
CORE RECOVERY

Type of hole . . . D = Diamond, H = Haystellite, S = Shot, C = Churn
Hole sealed . . . P = Packer, Cm = Cemented, Cs = Bottom of casing
Approx. size of hole (X-series) . . Ex = 1-1/2", Ax = 1-7/8", Bx = 2-3/8", Nx = 3"
Approx. size of core (X-series) . . Ex = 7/8", Ax = 1-1/8", Bx = 1-5/8", Nx = 2-1/8"
Outside dia. of casing (X-series). Ex = 1-13/16", Ax = 2-1/4", Bx = 2-7/8", Nx = 3-1/2"
Inside dia. of casing (X-series) . . Ex = 1-1/2", Ax = 1-29/32", Bx = 2-3/8", Nx = 3"

7-1337 (8-74)
Bureau of Reclamation

GEOLOGIC LOG OF DRILL HOLE

TABLE 6 SHEET 3 OF 4

FEATURE Collom Gulch Study Site PROJECT Emria STATE Colorado

HOLE NO. DH-2 LOCATION NE¼ SE¼ SEC. 32, T. 4, N, R. 94W. GROUND ELEV. 7335'± DIP (ANGLE FROM HORIZ.) 90.0 degrees Down

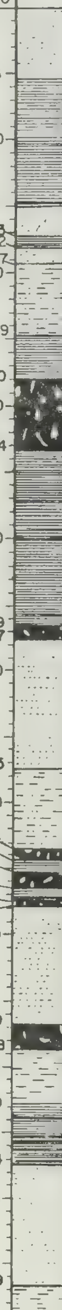
COORDS. N. .... E. ....

BEGUN 09-13-80 FINISHED 09-22-80 DEPTH OF OVERBURDEN 6.0' TOTAL DEPTH 326.9' BEARING ....

DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED Not Measured LOGGED BY D. Grundvig LOG REVIEWED BY F. Thompson

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS	TYPE AND SIZE OF HOLE	CORE RECOVERY (%)	SUITABILITY OF OVERBURDEN: SUITABLE	LIMITED SUITABILITY	UNSUITABLE	ELEVATION (FEET)	DEPTH (FEET)
	HQ wire-line (3½")	94		+		7135.0	200.0
				+		7129.7	205.3
	210	6		+			210
				+		7119.7	215.1
				+		7117.7	217.3
				+		7116.8	218.2
				+		7115.3	219.7
	220	100		+			220
				+		7110.1	224.9
		100		+		7107.0	228.0
	230	100			COAL		230
				+		7101.6	233.4
	240	100		+			240
		95			COAL	7088.1	246.9
				+		7087.3	247.7
	250	100		+			250
				+		7077.5	257.5
	260	100		+			260
					COAL	7071.6	263.4
				+		7070.5	264.5
					COAL	7069.9	265.1
				+		7068.3	266.7
					COAL	7066.5	268.5
				+		7066.1	268.9
	270	100		+			270
					COAL	7058.1	276.9
				+		7056.2	278.8
	280 HQ wire-line (3½")	100		+			280
				+		7052.1	282.9
					+	7047.6	287.4
	290	100			+		290
				+		7038.1	296.9
		100		+		7035.0	300.0

GRAPHIC LOG



SAMPLES FOR TESTING

CLASSIFICATION AND PHYSICAL CONDITION

184.2 - 185.1: Shale, carbonaceous in part.
185.1 - 186.9: Coal, with carbonaceous shale.
186.9 - 187.8: Shale
187.8 - 205.3: Sandstone, salt and pepper appearance in part, several near-vertical joints (lightly Fe stained) and partially cemented near center of interval.
205.3 - 215.1: Shale? only 0.6' recovered, remainder of interval unknown
215.1 - 217.3: Sandstone
217.3 - 218.2: Shale
218.2 - 219.7: Sandstone
219.7 - 224.9: Siltstone
224.9 - 228.0: Shale
228.0 - 233.4: Coal
233.4 - 246.9: Shale
246.9 - 247.7: Coal
247.7 - 257.5: Sandstone
257.5 - 263.4: Siltstone
263.4 - 264.5: Coal, not submitted for testing.
264.5 - 265.1: Shale
265.1 - 266.7: Coal
266.7 - 268.5: Shale
268.5 - 268.9: Coal
268.9 - 276.9: Sandstone, minor shale partings.
276.9 - 278.8: Coal
278.8 - 282.9: Siltstone, with few sandstone lenses.
282.9 - 287.4: Shale
287.4 - 296.9: Sandstone
296.9 - 300.4: Siltstone
300.4 - 301.8: Coal
301.8 - 305.7: Shale, some slickensides.
305.7 - 311.5: Siltstone
311.5 - 321.8: Sandstone
321.8 - 326.9: Shale

EXPLANATION

CORE LOSS
CORE RECOVERY

Type of hole . . . . . D = Diamond, H = Haystellite, S = Shot, C = Churn
Hole sealed . . . . . P = Packer, Cm = Cemented, Cs = Bottom of casing
Approx. size of hole (X-series) . . Ex = 1-1/2", Ax = 1-7/8", Bx = 2-3/8", Nx = 3"
Approx. size of core (X-series) . . Ex = 7/8", Ax = 1-1/8", Bx = 1-5/8", Nx = 2-1/8"
Outside dia. of casing (X-series) . Ex = 1-13/16", Ax = 2-1/4", Bx = 2-7/8", Nx = 3-1/2"
Inside dia. of casing (X-series) . . Ex = 1-1/2", Ax = 1-29/32", Bx = 2-3/8", Nx = 3"

FEATURE Collom Gulch Study Site PROJECT Emria STATE Colorado SHEET 3 OF 4 HOLE NO. DH-2

☆ GPO 879-482

GEOLOGIC LOG OF DRILL HOLE

TABLE 6 SHEET 4 OF 4

FEATURE Collom Gulch Study Site PROJECT Emria STATE Colorado

HOLE NO. DH-2 LOCATION NE¼, SE¼, SEC 32, T. 4 N., R. 94W. GROUND ELEV. 7335'± DIP (ANGLE FROM HORIZ.) 90.0 degrees Down

COORDS. N. E.

BEGUN 09-13-80 FINISHED 09-22-80 DEPTH OF OVERBURDEN 6.0' TOTAL DEPTH 326.9' BEARING

DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED Not Measured LOGGED BY D. Grundvig LOG REVIEWED BY F. Thompson

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS	TYPE AND SIZE OF HOLE	CORE RECOVERY (%)	SUITABILITY OF OVERBURDEN: SUITABLE	LIMITED SUITABILITY	UNSUITABLE	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	SAMPLES FOR TESTING	CLASSIFICATION AND PHYSICAL CONDITION
						7035.0	300.0			
		100		+		7034.6	300.4			
					COAL	7033.2	301.8			
				+		7029.3	305.7			
	310	100		+		7023.5	311.5			
	320	100		+		7013.2	321.8			
						7008.1	326.9			

TOTAL DEPTH 326.9'

EXPLANATION

CORE LOSS

CORE RECOVERY

Type of hole . . . . . . D = Diamond, H = Haystellite, S = Shot, C = Churn
Hole sealed . . . . . . P = Packer, Cm = Cemented, Cs = Bottom of casing
Approx. size of hole (X-series) . . Ex = 1-1/2", Ax = 1-7/8", Bx = 2-3/8", Nx = 3"
Approx. size of core (X-series) . . Ex = 7/8", Ax = 1-1/8", Bx = 1-5/8", Nx = 2-1/8"
Outside dia. of casing (X-series) . Ex = 1-13/16", Ax = 2-1/4", Bx = 2-7/8", Nx = 3-1/2"
Inside dia. of casing (X-series) . . Ex = 1-1/2", Ax = 1-29/32", Bx = 2-3/8", Nx = 3"

7-1337 (6-74)
Bureau of Reclamation

GEOLOGIC LOG OF DRILL HOLE

TABLE 6 SHEET 1 OF 3

FEATURE Collom Gulch Study Site PROJECT Emria STATE Colorado
HOLE NO. DH-3 LOCATION NW¼ NE¼, SEC 34, T4N, R 94W. GROUND ELEV. 7290± 1/ DIP (ANGLE FROM HORIZ.) 90.0 degrees Down
COORDS. N. ... E. ...
BEGUN 09-23-80 FINISHED 09-27-80 DEPTH OF OVERBURDEN 2.0' TOTAL DEPTH 306.6' BEARING ...
DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED Not Measured LOGGED BY D. Grundvig LOG REVIEWED BY F. Thompson

Driller: J. Dunn & K. Rasmussen, B.O.R.

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS

NOTE: 1/
All measurements are from the ground surface. Hole was not surveyed, deviation (if any) from vertical is unknown.

PURPOSE OF HOLE:
To obtain samples for determination of overburden properties.

DRILLING EQUIPMENT:
Skid-mounted Sprague and Henwood

DRILLING FLUID:
Water, recirculated

DRILLING FLUID LOSSES:
Drillers reported no water return from 0.0' to 36.5', no losses from 36.5' to 76.6', 80% loss from 76.6' to 156.6', no losses from 156.6' to 206.6, and 25 to 50% losses for the remainder of the hole.

CASING RECORD:

Cs Size (in.)	Depth of Cs (feet)	Hole Depth (feet)
-	-	20.0
4	19.0	20.0-306.6

HOLE COMPLETION:
Geophysical logs were run in hole by U.S.G.S.
Well points were installed with tips at 239.2' and 292.7' (10' influence zones) for ground water studies.
No unusual drilling conditions, other than loss of water, were reported by drillers.

TYPE AND SIZE OF HOLE / CORE RECOVERY / SUITABILITY OF OVERBURDEN

Depth interval (feet)	Type and size of hole	Core recovery (%)
0.0 - 20.0	RB	0
20.0 - 100.0	HQ Wire-line ($3\frac{1}{2}$")	100, 100, 96, 85, 100, 100, 100, 100, 100

Elevation (feet)	Depth (feet)	Suitability of overburden
7290.0	0.0	
7288.0	2.0	Suitable (0.0 - 2.0)
7267.5	22.5	Limited suitability
7262.4	27.6	Limited suitability
7249.0	41.0	Limited suitability
7243.2	46.8	Limited suitability
7241.3	48.7	Unsuitable – COAL
7230.5	59.5	Limited suitability
7227.8	62.2	Limited suitability
7213.6	76.4	Limited suitability
7211.4	78.6	Limited suitability
7210.6	79.4	Unsuitable – COAL
7207.2	82.8	Limited suitability
7206.3	83.7	Limited suitability
7203.0	87.0	Limited suitability
7197.5	92.5	Limited suitability
7196.2	93.8	Unsuitable – COAL
7190.0	100.0	Unsuitable

CLASSIFICATION AND PHYSICAL CONDITION

0.0 - 2.0: Lean Clay: Approximately 70% fines with medium plasticity, 30% fine sand, slight to moderate reaction with HCL, dark to light brown, dry. (CL)

2.0 - 306.6: Cretaceous Williams Fork Formation (Kw)
Interbedded sandstone, siltstone, shale, and coal. Individual units are described below.

Sandstone: principally quartzose but may be argillaceous and calcareous in part, very fine to medium, subangular to subrounded grains, fresh to moderately weathered, weakly to well cemented bedding indistinct, lightly jointed, black carbonaceous swirls and laminations in part, occasional slickensides, slight to moderate porosity, light gray to yellow brown, strong to no reaction with HCL. Core recovered in fragments and lengths to 3.0' (most are less than 1.5'). Most contacts are gradational.

Siltstone: carbonaceous and sandy in part, frequent shale partings, fresh to moderately weathered, moderately hard, moderately well cemented, indistinct bedding, lightly jointed, occasional near-vertical fractures and slickensides, light to dark gray, frequent leaf imprints, slight to strong reaction with HCL. Core recovered in 0.1' to 0.7' lengths. Most breaks are inclined approximately 8-10 degrees to the horizontal with rough, irregular surface. Most contacts are gradational.

Shale: carbonaceous and sandy in part, fresh to moderately weathered, slight to moderate air slaking, fissility poorly to moderately developed. Occasional slickensides, gray to black, slight to no reaction with HCL. Core recovered in fragments to 0.4' lengths. Most contacts are gradational.

EXPLANATION

CORE LOSS / CORE RECOVERY

RB = rock bit
Fe = oxides of iron, i.e. limonite, hematite
HCL = hydrochloric acid (10% solution)

Type of hole: D = Diamond, H = Haystellite, S = Shot, C = Churn
Hole sealed: P = Packer, Cm = Cemented, Cs = Bottom of casing
Approx. size of hole (X-series): Ex = 1-1/2", Ax = 1-7/8", Bx = 2-3/8", Nx = 3"
Approx. size of core (X-series): Ex = 7/8", Ax = 1-1/8", Bx = 1-5/8", Nx = 2-1/8"
Outside dia. of casing (X-series): Ex = 1-13/16", Ax = 2-1/4", Bx = 2-7/8", Nx = 3-1/2"
Inside dia. of casing (X-series): Ex = 1-1/2", Ax = 1-29/32", Bx = 2-3/8", Nx = 3"

7-1337 (6-74)
Bureau of Reclamation

GEOLOGIC LOG OF DRILL HOLE

FEATURE Collom Gulch Study Site PROJECT Emria STATE Colorado

HOLE NO. DH-3 LOCATION NW¼ NE¼, SEC 34, T4N, R. 94W. GROUND ELEV. 7290+ DIP (ANGLE FROM HORIZ.) 90.0 degrees Down

COORDS. N. .... E. ....

BEGUN 09-23-80 FINISHED 09-27-80 DEPTH OF OVERBURDEN 2.0' TOTAL DEPTH 306.6' BEARING ....

DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED Not Measured LOGGED BY D. Grundvig LOG REVIEWED BY F. Thompson

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS	TYPE AND SIZE OF HOLE	CORE RECOVERY (%)	SUITABILITY OF OVERBURDEN: SUITABLE	LIMITED SUITABILITY	UNSUITABLE	ELEVATION (FEET)	DEPTH (FEET)
						7190.0	100.0
		100				7183.7	106.3
	110	100				7173.8	116.2
						7171.3	118.7
	120	100				7169.2	120.8
					COAL	7163.9	126.1
	130	100			COAL	7159.6	130.4
						7158.7	131.3
						7153.3	136.7
	140	100				7148.0	142.0
	150	100				7138.5	151.5
						7136.6	153.4
						7134.2	155.8
						7131.3	158.7
	160	100				7128.7	161.3
					COAL	7124.2	165.8
	170	100				7121.0	169.0
						7112.5	177.5
	180	100				7106.1	183.9
						7103.5	186.5
	190	100				7101.0	189.0
						7098.3	191.7
						7095.9	194.1
					COAL	7094.4	195.6
		100				7092.6	197.4
						7090.0	200.0

GRAPHIC LOG | SAMPLES FOR TESTING

Driller: J. Dunn & K. Rasmussen
B.O.R.

CLASSIFICATION AND PHYSICAL CONDITION

Coal: dull to shiny black core recovered in fragments and lengths to 0.7'. Occasional shale parting.
2.0 - 22.5: Shale, intensely weathered, soft and crumbly.
22.5 - 27.6: Sandstone, Fe stained throughout.
27.6 - 41.0: Shale, occasional slickensides (70-85 degrees to the horizontal).
41.0 - 46.8: Sandstone
46.8 - 48.7: Coal
48.7 - 59.5: Shale
59.5 - 62.2: Sandstone, gray to white.
62.6 - 76.4: Siltstone, some coal streaks.
76.4 - 78.6: Shale
78.6 - 79.4: Coal
79.4 - 82.8: Sandstone
82.8 - 83.7: Siltstone
83.7 - 87.0: Shale, black.
87.0 - 92.5: Sandstone
92.5 - 93.8: Coal
93.8 - 106.3: Sandstone
106.3 - 116.2: Siltstone, carbonaceous in lower part.
116.2 - 118.7: Sandstone
118.7 - 120.8: Shale
120.8 - 126.1: Coal
126.1 - 130.4: Siltstone, shale parting at contact with coal.
130.4 - 131.3: Coal
131.3 - 136.7: Siltstone
136.7 - 142.0: Sandstone
142.0 - 151.5: Siltstone, with shale and sandstone lenses.
151.5 - 153.4: Sandstone
153.4 - 155.8: Shale, black.
155.8 - 158.7: Siltstone
158.7 - 161.3: Sandstone, salt and pepper appearance.
161.3 - 165.8: Siltstone
165.8 - 169.0: Coal
169.0 - 177.5: Sandstone
177.5 - 183.9: Siltstone, with shale lenses, dark gray to black.
183.9 - 186.5: Sandstone
186.5 - 189.0: Siltstone, with frequent shale partings.
189.0 - 191.7: Sandstone
191.7 - 194.1: Siltstone, several slickensides.
194.1 - 195.6: Shale
195.6 - 197.4: Coal
197.4 - 200.6: Sandstone
200.6 - 210.8: Siltstone, some black shale and coal streaks near bottom of interval.
210.8 - 231.4: Sandstone, slight Fe staining in part.

EXPLANATION

CORE LOSS
CORE RECOVERY

Type of hole .... D = Diamond, H = Haystellite, S = Shot, C = Churn
Hole sealed .... P = Packer, Cm = Cemented, Cs = Bottom of casing
Approx. size of hole (X-series) .. Ex = 1-1/2", Ax = 1-7/8", Bx = 2-3/8", Nx = 3"
Approx. size of core (X-series) .. Ex = 7/8", Ax = 1-1/8", Bx = 1-5/8", Nx = 2-1/8"
Outside dia. of casing (X-series). Ex = 1-13/16", Ax = 2-1/4", Bx = 2-7/8", Nx = 3-1/2"
Inside dia. of casing (X-series).. Ex = 1-1/2", Ax = 1-29/32", Bx = 2-3/8", Nx = 3"

☆GPO 679-482

7-1337 (8-74)
Bureau of Reclamation

GEOLOGIC LOG OF DRILL HOLE

FEATURE Collom Gulch Study Site PROJECT Emria STATE Colorado
HOLE NO. DH-3 LOCATION NW¼ NE¼, SEC 34, T4N R. 94W. COORDS. N. E. GROUND ELEV. 7290± DIP (ANGLE FROM HORIZ.) 90.0 degrees Down
BEGUN 09-23-80 FINISHED 09-27-80 DEPTH OF OVERBURDEN 2.0' TOTAL DEPTH 306.6' BEARING
DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED Not Measured LOGGED BY D. Grundvig LOG REVIEWED BY F. Thompson

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS	TYPE AND SIZE OF HOLE	CORE RECOVERY (%)	SUITABILITY OF OVERBURDEN	ELEVATION (FEET)	DEPTH (FEET)
				7090.0	200.0
			Unsuitable	7089.4	200.6
		100	Unsuitable – COAL	7087.6	202.4
		100	Unsuitable	7079.2	210.8
		100	Limited suitability	7058.6	231.4
		100	Unsuitable	7056.3	233.7
			Unsuitable – COAL	7054.4	235.6
		100	Unsuitable	7044.5	245.5
			Unsuitable – COAL	7042.0	248.0
		100	Unsuitable	7030.3	259.7
		100	Unsuitable – COAL	7028.1	261.9
		100	Limited suitability	7006.1	283.9
		100	Unsuitable – COAL	6994.6	295.4
		100	Limited suitability	6991.7	298.3
				6990.0	300.0
	HQ Wire-line		Limited suitability	6983.4	306.6

TOTAL DEPTH 306.6'

CLASSIFICATION AND PHYSICAL CONDITION

231.4 - 233.7: Siltstone, carbonaceous
233.7 - 235.6: Coal
235.6 - 245.5: Siltstone, black and carbonaceous in part.
245.5 - 248.0: Coal
248.0 - 259.7: Siltstone, with frequent shale lenses, light air slaking.
259.7 - 261.9: Coal
261.9 - 283.9: Sandstone, with frequent siltstone lenses to 0.3' thick.
283.9 - 295.4: Coal
295.4 - 298.3: Siltstone
298.3 - 306.6: Sandstone, laminated in upper part only.

CORE LOSS
CORE RECOVERY

Type of hole . . . D = Diamond, H = Haystellite, S = Shot, C = Churn
Hole sealed . . . P = Packer, Cm = Cemented, Cs = Bottom of casing
Approx. size of hole (X-series) . . Ex = 1-1/2", Ax = 1-7/8", Bx = 2-3/8", Nx = 3"
Approx. size of core (X-series) . . Ex = 7/8", Ax = 1-1/8", Bx = 1-5/8", Nx = 2-1/8"
Outside dia. of casing (X-series) . . Ex = 1-13/16", Ax = 2-1/4", Bx = 2-7/8", Nx = 3-1/2"
Inside dia. of casing (X-series) . . Ex = 1-1/2", Ax = 1-29/32", Bx = 2-3/8", Nx = 3"

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GEOLOGIC LOG OF DRILL HOLE

TABLE 6 SHEET 1 OF 2

FEATURE Collom Gulch Study Site PROJECT Emria Coal Study STATE Colorado

HOLE NO. DH-4 LOCATION NW¼ NW¼, SEC 3, T. 4 N., R. 94W. GROUND ELEV. 7570± 1/ DIP (ANGLE FROM HORIZ.) 90.0 degrees Down

COORDS. N. E.

BEGUN 10-02-80 FINISHED 10-17-80 DEPTH OF OVERBURDEN 4.0' TOTAL DEPTH 206.6' BEARING

DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED Not Measured LOGGED BY D. Grundvig LOG REVIEWED BY F. Thompson

ELEVATION (FEET)	DEPTH (FEET)	CORE RECOVERY (%)	SUITABILITY OF OVERBURDEN
7570.0	0.0	0	Suitable
7566.0	4.0		
7564.0	6.0		Limited suitability
7555.5	14.5	44	Unsuitable
		51	Unsuitable
7527.6	42.4	100	Limited suitability
7524.3	45.7		COAL
7522.2	47.8	100	Limited suitability
7520.7	49.3	100	Limited suitability
		100	Limited suitability
7498.8	71.2	100	
7496.5	73.5		COAL
7493.4	76.6	100	Limited suitability
7488.7	81.3		
7480.7	89.3	100	Limited suitability
7478.0	92.0		
7475.8	94.2		
7472.0	98.0		
7470.0	100.0		

TYPE AND SIZE OF HOLE: 0–14.5: 4½" RB; 14.5–100.0: HQ Wire-line (3½")

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS

NOTE: 1/
All measurements are from ground surface. Hole was not surveyed, deviation (if any) from vertical is unknown.

PURPOSE OF HOLE:
To obtain samples for determination of overburden properties.

DRILLING EQUIPMENT:
Skid-mounted Sprague and Henwood

DRILLING FLUID:
Water, recirculated

DRILLING FLUID LOSSES:
Driller reports 100% loss from 15.0 to the bottom of the hole (206.6').

CASING RECORD:

Cs Size (in.)	Depth of Cs (feet)	Depth of Hole (feet)
-	-	0.0-15.0
4	15.0	15.0-206.6

HOLE COMPLETION:
Driller twisted off core barrel and wire line in hole unable to retrieve. Hole was backfilled and abandoned.

CLASSIFICATION AND PHYSICAL CONDITION

Driller: J. Dunn & K. Rasmussen
B.O.R.

0.0 - 4.0: Lean Clay: Approximately 70% fines with medium plasticity, 30% fine sand, slight to moderate reaction with HCL, dark to light brown, dry. (CL)

4.0 - 206.6: Cretaceous Williams Fork Formation (Kw)
Interbedded sandstone, siltstone, shale, and coal. Individual units are described below.

Sandstone: principally quartzose but may be argillaceous in part, very fine to medium grained, subangular to subrounded grains, fresh to moderately weathered (mostly fresh), weakly to well cemented (most is moderately cemented), bedding indistinct, lightly jointed, frequent black laminations and swirls, occasional slickensides, slight to moderate porosity, gray to tan, slight to strong reaction with HCL. Core recovered in 0.1' to 2.0' lengths (most less than 1.0'). Most contacts are gradational.

Siltstone: carbonaceous and sandy in part, frequent shale partings, fresh to lightly weathered (Fe staining restricted to some joints), moderately hard, moderately well cemented, bedding indistinct, occasional joint inclined 30 degrees to 75 degrees to the horizontal, occasional slickensides, light to dark gray, slight to strong reaction with HCL. Core recovered in 0.1' to 1.5' lengths. Most breaks are approximately horizontal but rough and irregular. Most contacts are gradational.

Shale: carbonaceous and sandy in part, fresh to lightly weathered (Fe staining restricted to some breakage planes), slight to moderate air slaking, moderately cemented, fissility poorly to moderately developed. Gray to black, slight to no reaction to HCL. Core recovered in fragments to 0.3' lengths. Most contacts are gradational.

EXPLANATION

CORE LOSS / CORE RECOVERY

RB = rock bit
FE = oxides of iron, i.e. limonite and hematite
HCL = hydrochloric acid (10% solution)

Type of hole: D = Diamond, H = Haystellite, S = Shot, C = Churn
Hole sealed: P = Packer, Cm = Cemented, Cs = Bottom of casing
Approx. size of hole (X-series): Ex = 1-1/2", Ax = 1-7/8", Bx = 2-3/8", Nx = 3"
Approx. size of core (X-series): Ex = 7/8", Ax = 1-1/8", Bx = 1-5/8", Nx = 2-1/8"
Outside dia. of casing (X-series): Ex = 1-13/16", Ax = 2-1/4", Bx = 2-7/8", Nx = 3-1/2"
Inside dia. of casing (X-series): Ex = 1-1/2", Ax = 1-29/32", Bx = 2-3/8", Nx = 3"

FEATURE Collom Gulch Study Site PROJECT Emria STATE Colorado SHEET 1 OF 2 HOLE NO. DH-4

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GEOLOGIC LOG OF DRILL HOLE

TABLE 6 SHEET 2 OF 2

FEATURE Collom Gulch Study Site PROJECT Emria Coal Study STATE Colorado

HOLE NO. DH-4 LOCATION NW¼ NW¼, SEC 3, T. 4 N., R. 94W. GROUND ELEV 7570± DIP (ANGLE FROM HORIZ) 90.0 degrees Down

COORDS. N. .... E. ....

BEGUN 10-02-80 FINISHED 10-17-80 DEPTH OF OVERBURDEN 4.0' TOTAL DEPTH 206.6' BEARING ....

DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED Not Measured LOGGED BY D. Grundvig LOG REVIEWED BY F. Thompson

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS	TYPE AND SIZE OF HOLE	CORE RECOVERY (%)	SUITABILITY OF OVERBURDEN: SUITABLE	LIMITED SUITABILITY	UNSUITABLE	ELEVATION (FEET)	DEPTH (FEET)
						7470.0	100.0
	HQ Wire-line (3½")	100		+		7469.0	101.0
				+		7462.0	108.0
					COAL	7461.5	108.5
	110	100		+		7459.3	110.7
				+		7453.4	116.6
	120	100		+			120
	130	100		+		7439.6	130.4
				+		7433.1	136.9
	140	100		+			140
				+		7427.3	142.7
				+		7423.8	146.2
					COAL	7421.0	149.0
	150	100			COAL		150
				+		7416.6	153.4
				+		7415.5	154.5
				+		7412.0	158.0
	160	100		+			160
				+		7409.7	160.3
				+		7409.0	161.0
				+		7406.4	163.6
				+		7403.4	166.6
					COAL	7403.0	167.0
				+		7401.9	168.1
				+		7400.1	169.9
	170	100		+			170
				+		7396.2	173.8
				+		7395.0	175.0
				+		7391.7	178.3
	180 HQ Wire-line (3½")	100		+			180
					COAL	7388.0	182.0
				+		7386.4	183.6
					COAL	7382.1	187.9
				+		7381.1	188.9
	190	100		+			190
					COAL	7388.6	191.4
				+		7376.9	193.1
				+		7376.6	193.4
		100		+		7370.0	200.0
						7363.4	206.6

CORE LOSS
CORE RECOVERY

CLASSIFICATION AND PHYSICAL CONDITION

Coal: Dull to shiny black, mostly recovered in lengths less than 0.3'. Frequent thin carbonaceous shale partings.

4.0 - 6.0: Siltstone
6.0 - 14.5: Shale
14.5 - 42.4: Sandstone, friable on edges, some core body Fe stained. Numerous horizontal breaks (suspect mechanical breakage).
42.4 - 45.7: Shale; black, carbonaceous
45.7 - 47.8: Coal
47.8 - 49.3: Shale; black, carbonaceous
49.3 - 71.2: Sandstone; shale lense at 62.4' (0.8' thick).
71.2 - 73.5: Shale; black, carbonaceous
73.5 - 76.6: Coal
76.6 - 81.3: Shale; black, carbonaceous
81.3 - 92.0: Shale; 0.3' thick coal seam at 91.1.
92.0 - 94.2: Sandstone
94.2 - 98.0: Shale; black, carbonaceous
98.0 - 101.1: Sandstone
101.1 - 108.0: Siltstone; 1.2' thick sandstone lense at 106.1.
108.0 - 108.5: Shale
108.5 - 110.7: Coal
110.7 - 116.6: Shale
116.6 - 130.4: Sandstone; 0.6' thick seam of coal and carbonaceous shale at 122.4.
130.4 - 136.9: Shale; frequent slickensides (all orientations).
136.9 - 142.7: Siltstone
142.7 - 146.2: Sandstone; some slickensides oriented 5 degrees to 10 degrees to the horizontal.
146.2 - 149.0: Shale; numerous slickensides.
149.0 - 153.4: Coal
153.4 - 154.5: Shale; black, carbonaceous.
154.5 - 158.0: Sandstone
158.0 - 160.3: Siltstone
160.3 - 161.0: Shale
161.0 - 163.6: Siltstone
163.6 - 166.6: Sandstone
166.6 - 167.0: Shale; black, carbonaceous.
167.0 - 168.1: Coal
168.1 - 169.9: Siltstone
169.9 - 173.8: Sandstone
173.8 - 175.0: Siltstone
175.0 - 178.3: Shale; black, carbonaceous.
178.3 - 182.0: Sandstone
182.0 - 183.6: Coal
193.6 - 187.9: Shale; minor amounts pyrite in lower part.
187.9 - 188.9: Coal
188.9 - 191.4: Shale
191.4 - 193.1: Coal
193.1 - 193.4: Shale
193.4 - 206.6: Sandstone

FEATURE Collom Gulch Study Site PROJECT Emria STATE Colorado SHEET 2 OF 2 HOLE NO DH-4

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Bureau of Reclamation

GEOLOGIC LOG OF DRILL HOLE

TABLE 6 SHEET 1 OF 3

FEATURE Collom Gulch Study Site PROJECT Emria Coal Study STATE Colorado

HOLE NO DH-5 LOCATION SW¼ NE¼, SEC. 6, T. 3 N., R94W, GROUND ELEV. 7960.0± 1/ DIP (ANGLE FROM HORIZ.) 90.0 degrees Down

COORDS. N. E.

BEGUN 09-28-80 FINISHED 10-02-81 DEPTH OF OVERBURDEN 2.0' TOTAL DEPTH 306.6' BEARING ---

DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED Not Measured LOGGED BY D. Grundvig LOG REVIEWED BY F. Thompson

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS

NOTE: 1/
All measurements are from ground surface. Hole was not surveyed, deviation (if any) from vertical is unknown.

PURPOSE OF HOLE:
To obtain samples for determination of overburden properties.

DRILLING EQUIPMENT:
Skid-mounted Sprague and Henwood

DRILLING FLUID:
Water, recirculated

DRILLING FLUID LOSSES:
Driller reports 80-100% water losses 0.0 to 306.6

CASING RECORD:

Cs Size (in.)	Depth of Cs (ft.)	Depth of Hole (ft.)
-	-	0.0 - 20.0
4	20.0	20.0-306.6

HOLE COMPLETION:
Geophysical logs were run in hole by U.S.G.S.
Well points were installed with tips at 170.0 and 217.7. Length of influence zones not reported by driller.
No unusual drilling conditions reported other than no water circulation.

TYPE AND SIZE OF HOLE

RB (0.0–20.0); HQ Wire-line (3½") (20.0–100.0)

CORE RECOVERY (%)

0, 100, 100, 95, 100, 45, 100, 100, 100, 100, 100

SUITABILITY OF OVERBURDEN

Depth	Suitable	Limited Suitability	Unsuitable
0.0 – 2.0	+		
2.0 – 37.2		+	
37.2 – 39.4			COAL
39.4 – 100.0		+	

ELEVATION (FEET) / DEPTH (FEET)

Elevation (feet)	Depth (feet)
7960.0	0.0
	2.0
7937.9	22.1
7924.4	35.6
7922.8	37.2
7920.6	39.4
7903.5	56.5
7899.7	60.3
7898.2	61.8
7897.5	62.5
7896.6	63.4
7892.2	67.8
7888.5	71.5
7886.4	73.6
7873.3	86.7
7871.6	88.4
7870.1	89.9
7867.4	92.6
7863.2	96.8
7860.0	100.0

CLASSIFICATION AND PHYSICAL CONDITION

0.0 - 2.0: Lean Clay: Approximately 70% fines with medium plasticity, 30% fine sand, slight to moderate reaction with HCL, dark to light brown, dry. (CL).

2.0 - 306.6: Cretaceous Williams Fork Formation (Kw)
Interbedded sandstone, siltstone, shale, and coal. Individual units are described below.

Sandstone: principally quartzose but may be argillaceous and calcareous in part, very fine to medium grained, subangular to subrounded grains, fresh to moderately weathered, weakly to well cemented, bedding indistinct, lightly jointed, black carbonaceous swirls and laminations in part, occasional slickensides, slight to moderate porosity, light gray to yellow brown, strong to no reaction with HCL. Core recovered in fragments to 2.4' lengths (most less than 1.5). Most contacts are gradational.

Siltstone: carbonaceous and sandy in part, frequent shale partings, fresh to moderately weathered, moderately hard, moderately well cemented, indistinct bedding, lightly jointed, occasional near-vertical fractures and slickensides, frequent leaf imprints, slight to strong reaction with HCL. Core recovered in 0.1' to 0.7' lengths. Most breaks are inclined approximately 8-10 degrees to the horizontal with rough, irregular surfaces. Most contacts are gradational.

Shale: carbonaceous and sandy in part, fresh to moderately weathered, slight to moderate air slaking, fissility poorly to moderately developed. Occasional slickensides, gray to black, slight to no reaction with HCL. Core recovered in fragments to 0.4' lengths. Most contacts are gradational.

EXPLANATION

CORE LOSS
CORE RECOVERY

RB = rock bit
FE = oxides of iron, i.e. limonite and hematite
HCL = hydrochloric acid (10% solution)

Type of hole . . . D = Diamond, H = Haystellite, S = Shot, C = Churn
Hole sealed . . . P = Packer, Cm = Cemented, Cs = Bottom of casing
Approx. size of hole (X-series) . . Ex = 1-1/2", Ax = 1-7/8", Bx = 2-3/8", Nx = 3"
Approx. size of core (X-series) . . Ex = 7/8", Ax = 1-1/8", Bx = 1-5/8", Nx = 2-1/8"
Outside dia. of casing (X-series) . Ex = 1-13/16", Ax = 2-1/4", Bx = 2-7/8", Nx = 3-1/2"
Inside dia. of casing (X-series) . . Ex = 1-1/2", Ax = 1-29/32", Bx = 2-3/8", Nx = 3"

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Bureau of Reclamation

GEOLOGIC LOG OF DRILL HOLE

TABLE 6 SHEET 2 OF 3

FEATURE Collom Gulch Study Site PROJECT Emria Coal Study STATE Colorado

HOLE NO. DH-5 LOCATION SW¼ NE¼ SEC 6 T.3.N. R94W. GROUND ELEV. 7960± 1/ DIP (ANGLE FROM HORIZ.) 90.0 degrees Down

COORDS. N. E.

BEGUN 09-28-80 FINISHED 10-02-81 DEPTH OF OVERBURDEN 2.0' TOTAL DEPTH 306.6' BEARING

DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED Not Measured LOGGED BY D. Grundvig LOG REVIEWED BY F. Thompson

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS	TYPE AND SIZE OF HOLE	CORE RECOVERY (%)	SUITABILITY OF OVERBURDEN: SUITABLE	LIMITED SUITABILITY	UNSUITABLE	ELEVATION (FEET) 78600	DEPTH (FEET) 1000	GRAPHIC LOG	SAMPLES FOR TESTING
	HQ Wire-line ($3\frac{1}{2}$")	100			COAL	7857.5	102.5		
						7855.4	104.6		
						7852.5	107.5		
	110	100			COAL	7850.4	109.6		
						7844.9	115.1		
	120	100				7842.9	117.1		
						7836.4	123.6		
	130	100							
	140	100							
	150	100			COAL	7812.8	147.2		
						7808.4	151.6		
						7806.7	153.3		
						7803.2	156.8		
	160	100			COAL	7802.3	157.7		
						7798.5	161.5		
	170	100				7787.9	172.1		
					COAL	7786.8	173.2		
						7784.8	175.2		
	180	100				7782.5	177.5		
	190 HQ Wire-line ($3\frac{1}{2}$")	100				7765.9	194.1		
						7764.4	195.6		
		100			COAL	7760.3	199.7		
						7760.0	200.0		

CLASSIFICATION AND PHYSICAL CONDITION

Coal: dull to shiny black, mostly recovered in fragments to 0.6' lengths. Frequent, thin carbonaceous shale partings.

2.0 - 22.1: Shale, mod. Fe staining
22.1 - 35.6: Sandstone, intense Fe staining
35.6 - 37.2: Shale
37.2 - 39.4: Coal
39.4 - 56.5: Shale; black, carbonaceous
56.5 - 60.3: Sandstone, gray.
60.3 - 61.8: Shale
61.8 - 62.5: Sandstone, gray.
62.5 - 63.4: Siltstone
63.4 - 67.8: Sandstone, gray.
67.8 - 71.5: Shale, black, carbonaceous
71.5 - 73.6: Siltstone, minor coal seam at 73.3.
73.6 - 86.7: Sandstone, slickensides inclined 45 degrees at 75.5', high-angle breaks for next foot (partially healed-intense Fe staining).
86.7 - 88.4: Shale with coal laminations.
88.4 - 89.9: Sandstone, gray
89.9 - 92.6: Shale
92.6 - 96.8: Sandstone
96.8 - 102.5: Shale
102.5 - 104.6: Coal
104.6 - 107.5: Siltstone
107.5 - 109.6: Sandstone, 4 breaks inclined approximately 10 degrees to the horizontal.
109.6 - 115.1: Coal
115.1 - 117.1: Sandstone
117.1 - 123.6: Siltstone, with minor shale lenses throughout.
123.6 - 147.2: Sandstone, numerous siltstone lenses, slickensides at 144.0 (inclined 35 degrees to the horizontal).
147.2 - 151.6: Coal
151.6 - 153.3: Shale
153.3 - 156.8: Sandstone
156.8 - 157.7: Shale
157.7 - 161.5: Coal
161.5 - 172.1: Sandstone with minor shale partings.
172.1 - 173.2: Siltstone
173.2 - 175.2: Coal
175.2 - 177.5: Shale; black, carbonaceous.
177.5 - 194.1: Sandstone, dark gray to white, salt and pepper appearance near middle of interval. Lengths to 2.4'.
194.1 - 195.6: Siltstone
195.6 - 199.7: Coal
199.7 - 208.1: Shale with occasional coal streaks.
208.1 - 224.6: Sandstone

EXPLANATION

CORE LOSS
CORE RECOVERY

Type of hole . . . . . D = Diamond, H = Haystellite, S = Shot, C = Churn
Hole sealed . . . . . P = Packer, Cm = Cemented, Cs = Bottom of casing
Approx. size of hole (X-series) . . Ex = 1-1/2", Ax = 1-7/8", Bx = 2-3/8", Nx = 3"
Approx. size of core (X-series) . . Ex = 7/8", Ax = 1-1/8", Bx = 1-5/8", Nx = 2-1/8"
Outside dia. of casing (X-series). Ex = 1-13/16", Ax = 2-1/4", Bx = 2-7/8", Nx = 3-1/2"
Inside dia. of casing (X-series) . Ex = 1-1/2", Ax = 1-29/32", Bx = 2-3/8", Nx = 3"

7-1337 (8-74)
Bureau of Reclamation

GEOLOGIC LOG OF DRILL HOLE

TABLE 6 SHEET 3 OF 3

FEATURE Collom Gulch Study Site PROJECT Emria Coal Study STATE Colorado

HOLE NO. DH-5 LOCATION SW¼ NE¼ SEC6 T.3 N. R.94W. GROUND ELEV. 7960+ 1/ DIP (ANGLE FROM HORIZ.) 90.0 degrees Down

COORDS. N. E.

BEGUN 09-28-80 FINISHED 10-02-81 DEPTH OF OVERBURDEN 2.0' TOTAL DEPTH 306.6' BEARING

DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED Not Measured LOGGED BY D. Grundvig LOG REVIEWED BY F. Thompson

Column headings: NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS | TYPE AND SIZE OF HOLE | CORE RECOVERY (%) | SUITABILITY OF OVERBURDEN: SUITABLE, LIMITED SUITABILITY, UNSUITABLE | ELEVATION (FEET) 7760.0 | DEPTH (FEET) 200.0 | GRAPHIC LOG | SAMPLES FOR TESTING | CLASSIFICATION AND PHYSICAL CONDITION

Type and size of hole: HQ Wire-line ($3\frac{1}{2}$") (200–290); HQ Wire-line ($3\frac{1}{2}$") (290–306.6)

Core recovery: 100 for each run

Elevation (feet)	Depth (feet)	Suitability of overburden
7751.9	208.1	Limited suitability
7735.4	224.6	Limited suitability
7731.3	228.7	Unsuitable: COAL
7728.0	232.0	Limited suitability
7726.5	233.5	Limited suitability
7722.4	237.6	Limited suitability
7721.6	238.4	Unsuitable: COAL
7710.9	249.1	Unsuitable
7701.8	258.2	Limited suitability
7674.3	285.7	Unsuitable: COAL
7668.1	291.9	Limited suitability
7663.6	296.4	Limited suitability
7660.0	300.0	Limited suitability
7656.9	303.1	Limited suitability
7653.4	306.6	

224.6 - 228.7: Siltstone
228.7 - 232.0: Coal
232.0 - 233.5: Siltstone
233.5 - 237.6: Sandstone
237.6 - 238.4: Siltstone
238.4 - 249.1: Coal
249.1 - 258.2: Siltstone
258.2 - 285.7: Sandstone
285.7 - 291.9: Coal
291.9 - 296.4: Sandstone
296.4 - 303.1: Siltstone
303.1 - 306.6: Sandstone

CORE LOSS / CORE RECOVERY

Type of hole . . . . . D = Diamond, H = Haystellite, S = Shot, C = Churn
Hole sealed . . . . . P = Packer, Cm = Cemented, Cs = Bottom of casing
Approx. size of hole (X-series) . . Ex = 1-1/2", Ax = 1-7/8", Bx = 2-3/8", Nx = 3"
Approx. size of core (X-series) . . Ex = 7/8", Ax = 1-1/8", Bx = 1-5/8", Nx = 2-1/8"
Outside dia. of casing (X-series) . Ex = 1-13/16", Ax = 2-1/4", Bx = 2-7/8", Nx = 3-1/2"
Inside dia. of casing (X-series) . . Ex = 1-1/2", Ax = 1-29/32", Bx = 2-3/8", Nx = 3"

GPO 679-482

Symbols & Abbreviations most commonly used by USBR

Soil Profile Symbols

Cb	Cobble
Gr	Gravel
S	Sand
LS	Loamy Sand
SL	Sandy Loam
L	Loam
SiL	Silt Loam
SiCL	Silty Clay Loam
CL	Clay Loam
C	Clay
SiC	Silty Clay
HC	Heavy Clay
MS	Mudstone
Sh	Shale
SS	Sandstone

Land Use

C – Irrigated cultivated
P – Irrigated grassland
L – Nonirrigated cultivated
G – Nonirrigated grassland
B – Brush or timber
H – Suburban or homestead
I – Idle

Mapping Symbol

3 st / P3 LH Sh hw

Soil Deficiency
Topography Deficiency
Land Suitability Class
Information Symbols
Land Use
Underlaying Geologic Material
Depth of Suitable Soil
Next Significant Soil Layer Texture
Surface Soil Texture

Key to Laboratory Determination

Hydraulic Conductivity fragment Samples
Electrical conductivity of saturation extract
Settling Volume
pH of 1 5

02
5.5-64-pH (Ca Cl 2)

1 — 6st / B6SH — Sh, COAL, Sh
45% SLOPE
POINT OF RIDGE
ROCK OUTCROPS

2 — 2 st / B2LLSS g — L, L, SS
OAK
15 20% ROLLING INTO DRAW
DARK FRIABLE SOIL, SANDSTONE
BELOW 22"

3 — 2 st / B2LH Sh r — SH
SAGEBRUSH, GRASSES
5% SLOPE TO NW
STONY SURFACE
WEATHERED SHALE BELOW 14"
ROOT PENETRATION TO 36"

4 — 6st / B6 r
SAGEBRUSH, GRASSES
SERVICEBERRY
SURFACE SANDSTONE
22% SLOPE

5 — 2 st / B2LSS r — L
SERVICEBERRY, GRASSES
10% SLOPE
RIDGETOP
FLOAT ROCK AT 12"

6 — 2 st / B2LM r — L, CL
SAGEBRUSH, SERVICEBERRY
GRASSES
STOPPED BY FLOAT ROCK AT 18"

7 — 2 st / B2LL r — L
SERVICEBERRY, GRASSES
10% SLOPE TO SOUTH
STOPPED BY FLOAT ROCK AT 18"

AH-20 — B2HHSH — C, C, SH, SH
SAGEBRUSH, NATIVE GRASSES
10% SLOPE TO NORTH

AH-21 — 3st / B3H Sh — C, SH, SH
SAGEBRUSH, SERVICEBERRY
NATIVE GRASSES
13% SLOPE TO NW

USGS OBS WELL #1 — L; 15' SS; 17' SS; 20' COAL; 25'
LOAM TO SAND LOAM
DARK COLOR
BROKEN SANDSTONE YELLOWISH
BROWN COLOR
WEATHERED (SOFT) SANDSTONE
COAL · TO 25+ FEET WATER
TABLE STABLIZED AT 22' LEVEL
PRIOR TO INSTALLATION OF
SLOTTED 25+ PIPE

USGS OBS WELL — SiCL; 1; CL; 4; SCL; 6; 11; C; 13; 14; Gr C; 17; Gr C; 22'; SS
SANDSTONE FLOAT THROUGHOUT
PROFILE. FEW FINE SAND LENSES
SANDSTONE FLOAT ROCK IN CLAY
MATRIX VERY MOIST ZONE ON
FREE WATER.
GRAVEL WITH CLAY MATRIX
SANDSTONE BELOW 22' RED COLOR

4 th Section	1	2	3	Total	1	2	3	Total	Total Suitable	6	R.O.W.	Other	Grand Total
NE		38 9		38.9					38 9	125.03			163.93
NW		278		27.8					27.8	135.51			163. 31
SW		50.0		50.0					50.0	110.0			160.0
SE		2.8	227	25.5					25.5	134.5			160.0
TOTAL		119.5	22.7	142.2					142. 2	505.04			647. 24

UNITED STATES
Department of the Interior
Bureau of Reclamation

COLLOM GULCH SITE EMRIA PROJECT

LAND CLASSIFICATION

Classified by: McCOY Planimetered by JIBSON

Date OCT 1981 Photo No. C077G 1-6-196

Sec. 3 T. 3N. R. 94 W.

Salt Lake City, Utah

Symbols & Abbreviations most commonly used by U.S.B.R.

Soil Profile Symbols

Cb	Cobble
Gr	Gravel
S	Sand
LS	Loamy Sand
SL	Sandy Loam
L	Loam
SiL	Silt Loam
SiCL	Silty Clay Loam
CL	Clay Loam
C	Clay
SiC	Silty Clay
HC	Heavy Clay
MS	Mudstone
Sh	Shale
SS	Sandstone

Land Use

C – Irrigated cultivated
P – Irrigated grassland
L – Nonirrigated cultivated
G – Nonirrigated grassland
B – Brush or timber
H – Suburban or homestead
I – Idle

Mapping Symbol

$\frac{3\ \text{st}}{\text{P3 LH Sh}}\ \text{hw}$

Soil Deficiency — 3 st — Topography Deficiency
Land Suitability Class — Information Symbols
Land Use — Underlaying Geologic Material
Depth of Suitable Soil — Next Significant Soil Layer Texture
Surface Soil Texture

Key to Laboratory Determination

Hydraulic Conductivity fragment Samples — 0 2 — Electrical conductivity of saturation extract
Settling Volume — 5.5-64-pH (Ca Cl 2) — pH of 1:5

1 (L / L / SS) — $\frac{2\ \text{st}}{\text{B2LLSS}}$ g
SAGEBRUSH,
SERVICEBERRY
15% SLOPE

AH-18 (.40 CL 78 / .26 C 86 / .40 SH 87 / .22 SH 89 / .03 SH 8.7 / .05 MS 88) — $\frac{2\ \text{st}}{\text{B2LMSH}}$ g
SAGEBRUSH, GRASSES
9% SLOPE TO NW

2 (L / L / SS) — $\frac{2\ \text{st}}{\text{B2LLSS}}$ g
SAGEBRUSH, SERVICEBERRY,
OAK
ROLLING SIDESLOPE
14-18% SLOPE

3 (L / SS & MS) — $\frac{3\ \text{st}}{\text{B3LM MS}}$
SAGEBRUSH, GRASSES
15% SIDESLOPE
ROCK ON SURFACE

DH-4 (AH-17) (CL / SiCL / MS / MS) — $\frac{2\ \text{st}}{\text{B2MHMS}}$
SAGEBRUSH, GRASSES
SNOWBERRY
6% SLOPE - RIDGETOP

4 (L / COAL / SH) — $\frac{6\ \text{st}}{\text{B6L Sh}}$ g
SAGEBRUSH,
SERVICEBERRY
50% SLOPE
SLUMP AREA
SEEPS IN COAL OUTCROPS

5 (79 L 72 / 22 CL 76 / .15 SH 71) — $\frac{2\ \text{st}}{\text{B2LMSh}}$
SAGEBRUSH
14% SLOPE

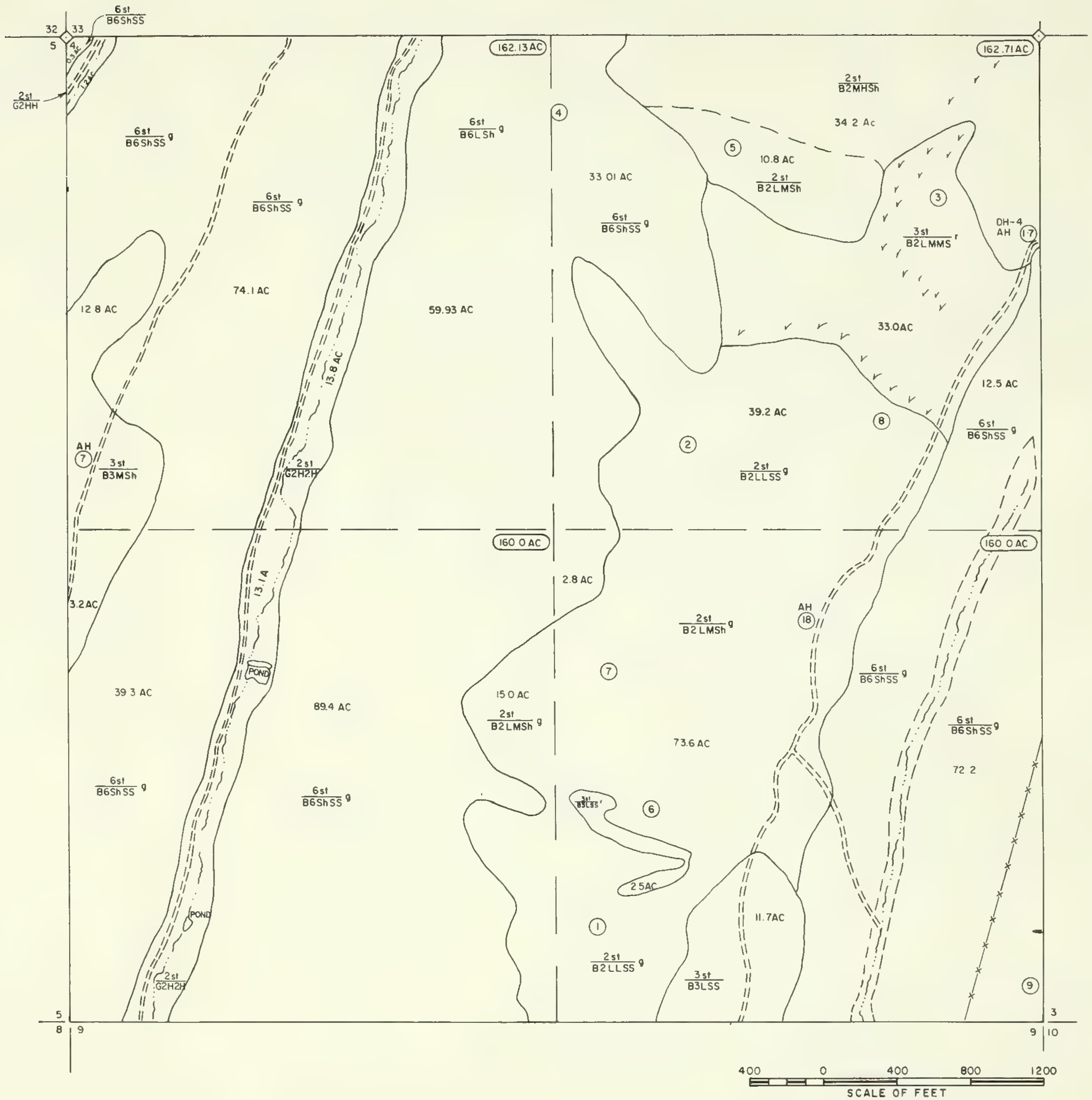
6 (CL / C / C / SH) — $\frac{2\ \text{st}}{\text{B2MH Sh}}$
SAGEBRUSH, GRASSES
10% SLOPE

7 (L / CL / CL / SS) — $\frac{2\ \text{st}}{\text{B2MMSS}}$
SAGEBRUSH, GRASSES
10% SLOPE

8 (L / CL / SS) — $\frac{2\ \text{st}}{\text{B2LMSS}}$
SAGEBRUSH, GRASSES
12% SLOPE

AH-7 (CL / SH / SS) — $\frac{3\ \text{st}}{\text{B3MSh}}$
OAK, SERVICEBERRY, GRASSES,
SAGEBRUSH, SNOWBERRY
8% SLOPE

9 (C / COAL / SH / MS) — $\frac{6\ \text{st}}{\text{B3HSh}}$ g
SAGEBRUSH
RIDGETOP
SURFACE ROCK



4 th Section	1	2	3	Total	1	2	3	Total	Total Suitable	6	R.O.W.	Other	Grand Total
NE		84 2	33 0	117 2					117 2	45 51			162 71
NW		15 0	12 8	27 8					27 8	134 33			162 13
SW		28.1	3.2	31.3					31 3	128.7			160.0
SE		76.1	11.7	87 8					87.8	72 2			160 0
TOTAL		203 4	60.7	264 1					264.1	380.74			644 84

UNITED STATES
Department of the Interior
Bureau of Reclamation

COLLOM GULCH SITE EMRIA PROJECT
LAND CLASSIFICATION

Classified by: McCOY Planimetered by JIBSON
Date OCT 1981 Photo No CO77G 1-6-196

Sec. 4 T. 3N. R. 94W.
Salt Lake City, Utah

Symbols & Abbreviations most commonly used by U.S.B.R.

Soil Profile Symbols

Cb	Cobble
Gr	Gravel
S	Sand
LS	Loamy Sand
SL	Sandy Loam
L	Loam
SiL	Silt Loam
SiCL	Silty Clay Loam
CL	Clay Loam
C	Clay
SiC	Silty Clay
HC	Heavy Clay
MS	Mudstone
Sh	Shale
SS	Sandstone

Land Use

C – Irrigated cultivated
P – Irrigated grassland
L – Nonirrigated cultivated
G – Nonirrigated grassland
B – Brush or timber
H – Suburban or homestead
I – Idle

Mapping Symbol

$$\frac{3\ st}{P3\ L\ H\ Sh}\ \boxed{hw}$$

Soil Deficiency
Topography Deficiency
Land Suitability Class
Information Symbols
Land Use
Underlaying Geologic Material
Depth of Suitable Soil
Next Significant Soil Layer Texture
Surface Soil Texture

Key to Laboratory Determination

Hydraulic Conductivity fragment Samples
Settling Volume
Electrical conductivity of saturation extract
0 2
5.5-64-pH (CaCl2)
pH of 1:5

1 — SCL, C, SS
$\frac{2S}{B2MHSH}$
BLACK SAGEBRUSH, GRASSES
SERVICEBERRY
10% SLOPE

2 — HC, SH
$\frac{3st}{B3H\ SH}$
BLACK SAGEBRUSH
GRASSES, SERVICEBERRY

3 — HC, SH
$\frac{2S}{B2MHSH}$
SAGEBRUSH, GRASSES
SERVICEBERRY
12% SLOPE NE

4 — C, SH
$\frac{3st}{B3HSH}$
SAGEBRUSH, GRASSES
SERVICEBERRY
23% SLOPE EAST

5 — C
$\frac{1}{G1MH}$
MEADOW GRASSES
3% SLOPE NORTH
MOTTLING FROM SURFACE DOWN
FREE WATER AT 28"

6 — CL, S, C, L
$\frac{1}{G1MH}$
TALL WHEATGRASS
RABBITBRUSH, SAGEBRUSH
3% SLOPE SOUTH

7 — CL, C
$\frac{1}{G1MH}$
MEADOW GRASSES, TALL
WHEATGRASS, BOX ELDER TREES
6% SLOPE NORTH
CANYON BOTTOMLANDS

8 — C, SS
$\frac{2S}{B2MHSH}$
SAGEBRUSH, GRASSES
SERVICEBERRY

9 — L, SS
$\frac{3st}{B3LSS}$
SAGEBRUSH, GRASSES
SERVICEBERRY
SANDSTONE FLOAT ROCK
19% SLOPE WEST

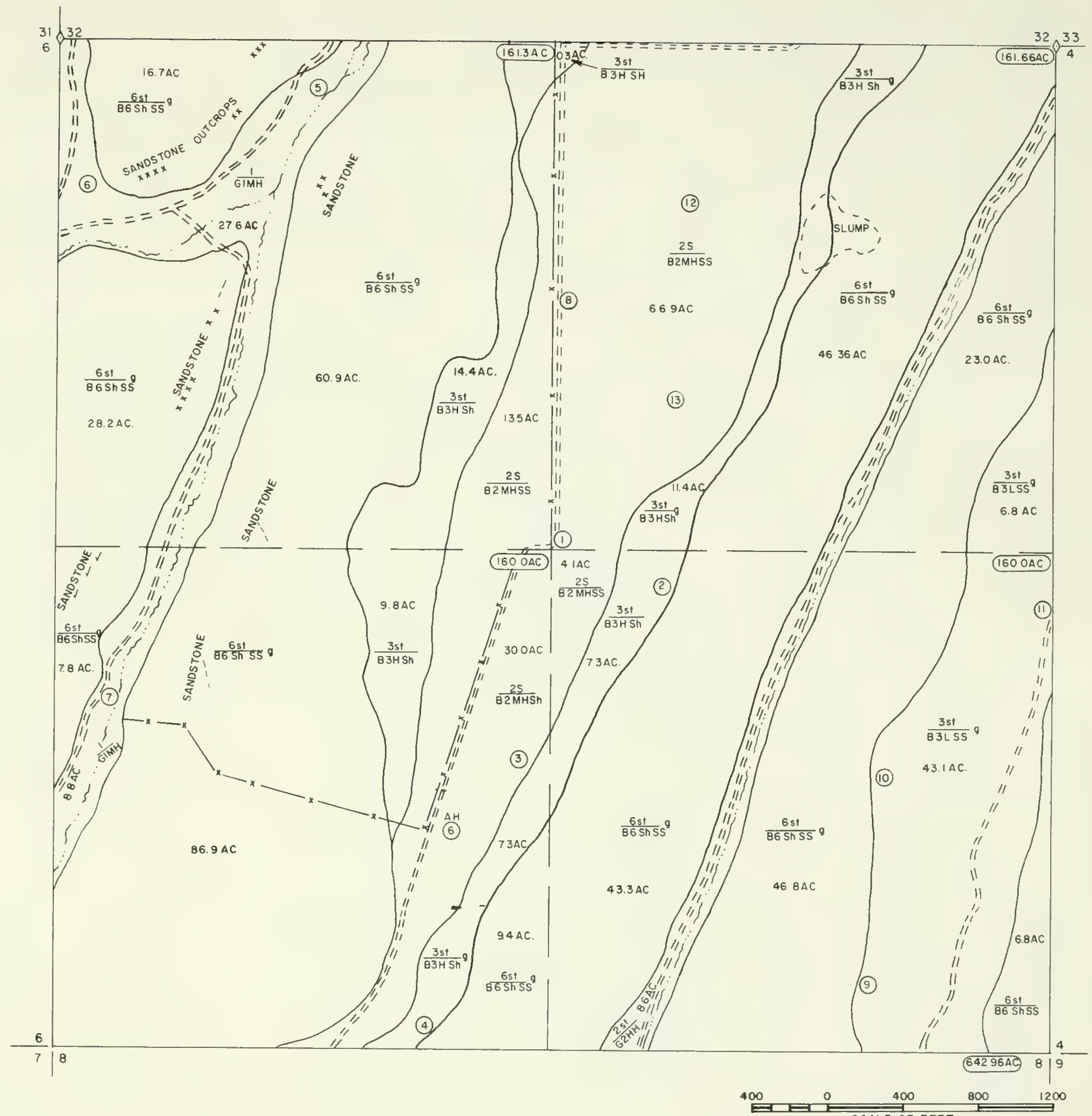
10 — L, SS
$\frac{3st}{B3L\ SS}$
SAGEBRUSH, GRASSES
SERVICEBERRY
SANDSTONE FLOAT ROCK
24% SLOPE WEST

11 — L
$\frac{3st}{B3L\ SS}$
SAGEBRUSH, GRASSES
SERVICEBERRY
NARROW RIDGETOP
16% SLOPE
SANDSTONE FLOAT ROCK

AH-6 — L, CL, SH, SH, SH, SH, SS
28, .63, .05, .32, .28, .02, .10
7.3, 7.2, 8.3, 8.5, 8.2, 8.5, 8.4
$\frac{2S}{B2MHSH}$
SAGEBRUSH & GRASSES
RIDGETOP
6% SLOPE

12 — L, C, C, SS
$\frac{2S}{B2MHSH}$
SAGEBRUSH, GRASSES
10-15% SIDESLOPE
6% SLOPE DOWN RIDGE

13 — SL, CL, CL, SS
$\frac{2S}{B2MHSH}$
SERVICEBERRY, DEAD SAGE
SEEP AREA
10% SLOPE TO EAST



UNITED STATES
Department of the Interior
Bureau of Reclamation

COLLOM GULCH SITE EMRIA PROJECT

LAND CLASSIFICATION

Classified by: J. R. Mc COY Planimetered by J. JIBSON
Date SEPT. 19 81 Photo No. CO77G 1-8-198

Sec. 5 T. 3 N R. 94 W.
Salt Lake City, Utah

4 th Section	1	2	3	Total	1	2	3	Total	Total Suitable	6	R.O.W.	Other	Grand Total
NE		73.8	18.5	92.3					92.3	69.36			161.66
NW	27.6	13.5	14.4	55.5					55.5	105.8			161.3
SW	8.8	30.0	17.1	55.9					55.9	104.1			160.0
SE		12.7	50.4	63.1					63.1	96.9			160.0
TOTAL	36.4	130.0	100.4	266.8					266.8	376.16			642.96

Symbols & Abbreviations most commonly used by U S B R.

Soil Profile Symbols

Symbol	Meaning
Cb	Cobble
Gr	Gravel
S	Sand
LS	Loamy Sand
SL	Sandy Loam
L	Loam
SiL	Silt Loam
SiCL	Silty Clay Loam
CL	Clay Loam
C	Clay
SiC	Silty Clay
HC	Heavy Clay
MS	Mudstone
Sh	Shale
SS	Sandstone

Land Use

C – Irrigated cultivated
P – Irrigated grassland
L – Nonirrigated cultivated
G – Nonirrigated grassland
B – Brush or timber
H – Suburban or homestead
I – Idle

Mapping Symbol

Soil Deficiency — Topography Deficiency
Land Suitability Class — Information Symbols
3 st / P3 LH Sh — hw
Land Use — Underlaying Geologic Material
Depth of Suitable Soil — Next Significant Soil Layer Texture
Surface Soil Texture

Key to Laboratory Determination

Hydraulic Conductivity fragment Samples — Electrical conductivity of saturation extract
0 2
Settling Volume — 5 5-64-pH (CaCl2)
pH of 1 5

1 — 3st / B3MSh g — C / Sh
SERVICEBERRY, GRASSES
SAGEBRUSH
4 TO 20% SLOPE
SANDSTONE FLOAT ROCK

2 — 3st / B3MHSS g — C / Δ
SERVICEBERRY, GRASSES
SAGEBRUSH
26% SLOPE TO EAST

3 — 3st / B3MHSS g — C / SH
SERVICEBERRY
20% SLOPE TO EAST

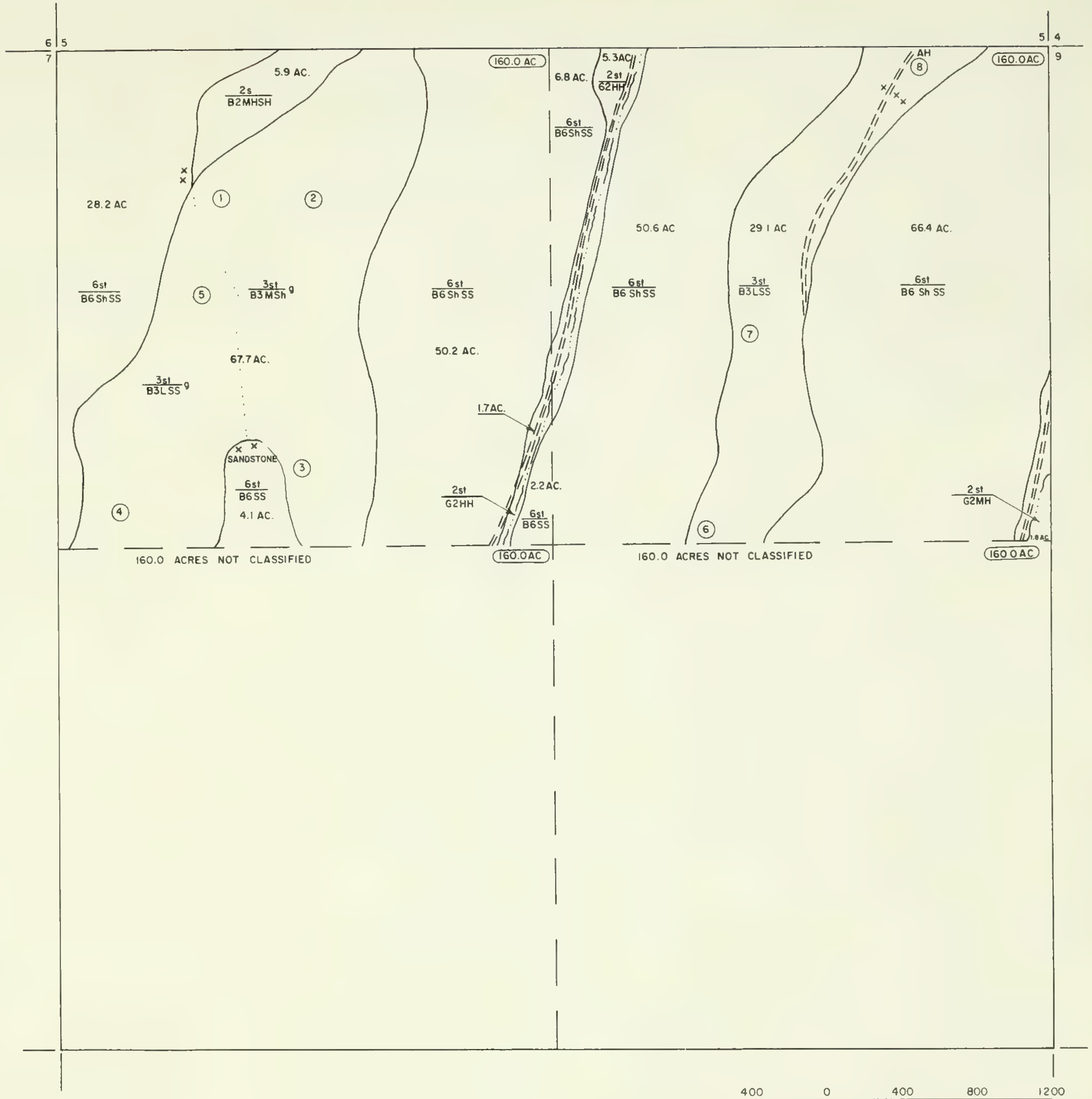
4 — 3st / B3LSS g — L / Δ
SAGEBRUSH, GRASSES
OAK, SERVICEBERRY
14% SLOPE TO EAST
NARROW RIDGE TOP

5 — 3st / B3LSS g — L / Δ
SERVICEBERRY, GRASSES, OAK
SAGEBRUSH
16% SLOPE
NARROW RIDGE TOP

6 — 3st / B3MSS g — L / Δ
SAGEBRUSH, GRASSES
24% SLOPE TO WEST
NARROW RIDGE TOP
SURFACE FLOAT ROCK

7 — 3st / B3LSS g — L / Δ
SERVICEBERRY, SAGEBRUSH
GRASSES
24 TO 30% SLOPE TO WEST
SANDSTONE FLOAT ROCK

AH–8 — 3st / B3MSS
SAGEBRUSH, GRASSES
.87 CL 7.6
.19 SS 8.8
.20 SH 8.1
.31 COAL 1.78 / 5.2
.14 SH 5.8



400 0 400 800 1200
SCALE OF FEET

4 th Section									Total Suitable	6	R O W	Other	Grand Total
	1	2	3	Total	1	2	3	Total					
NE		7.1	29 1	36. 2					36 2	123 8			160.0
NW		7.6	67. 7	75 3					75. 3	84 7			160 0
SW													
SE													
TOTAL		14.7	96.8	111.5					111 5	208.5			320 0

UNITED STATES
Department of the Interior
Bureau of Reclamation

COLLOM GULCH SITE EMRIA PROJECT
LAND CLASSIFICATION

Classified by McCOY Planimetered by JIBSON
Date OCT 19 81 Photo No CO77G 1-7-239
Sec. 8 T. 3N. R. 94W.
Salt Lake City, Utah

Symbols & Abbreviations most commonly used by U.S.B.R.

Soil Profile Symbols

Cb	Cobble
Gr	Gravel
S	Sand
LS	Loamy Sand
SL	Sandy Loam
L	Loam
SiL	Silt Loam
SiCL	Silty Clay Loam
CL	Clay Loam
C	Clay
SiC	Silty Clay
HC	Heavy Clay
MS	Mudstone
Sh	Shale
SS	Sandstone

Land Use

C – Irrigated cultivated
P – Irrigated grassland
L – Nonirrigated cultivated
G – Nonirrigated grassland
B – Brush or timber
H – Suburban or homestead
I – Idle

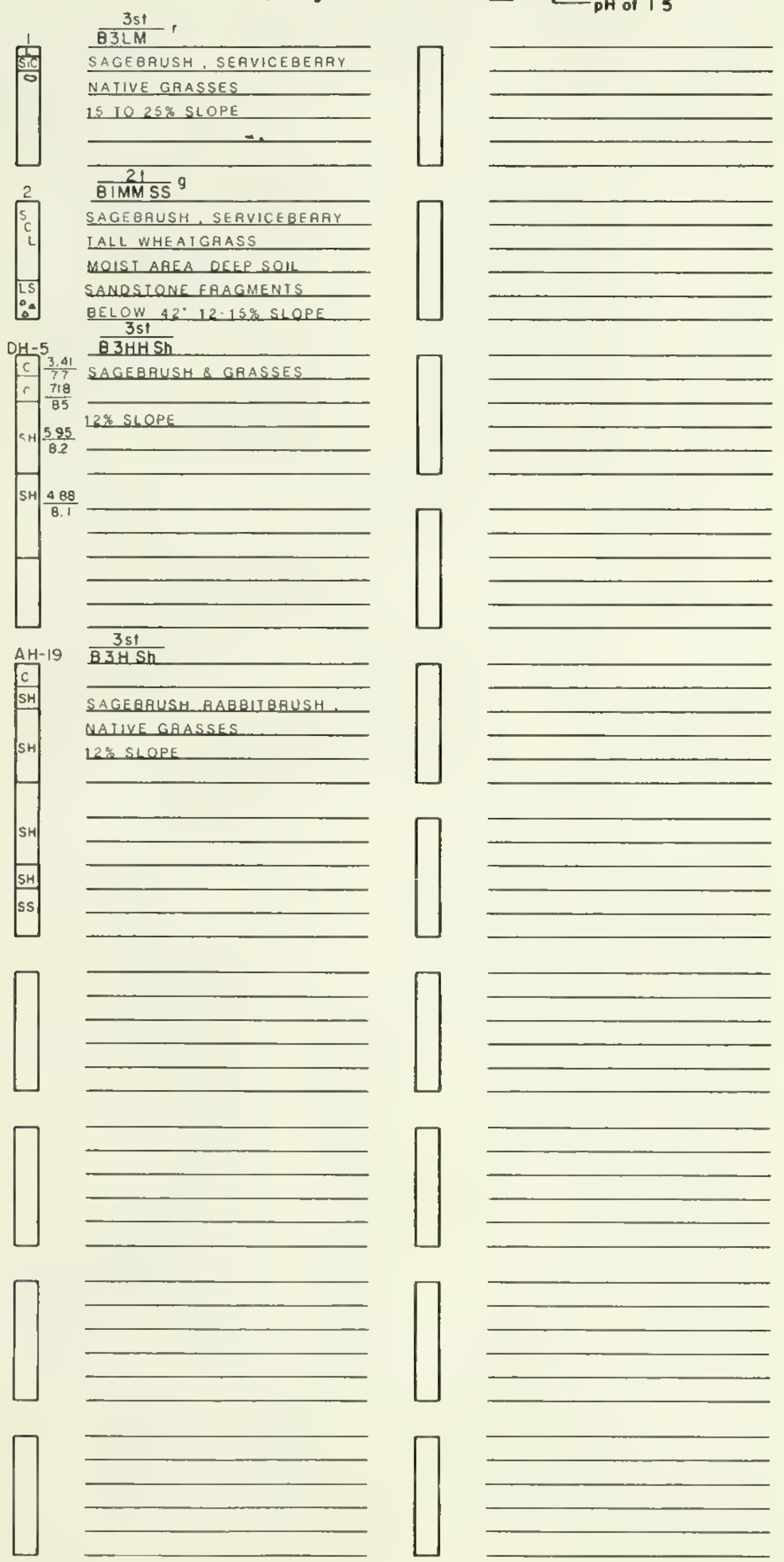
Mapping Symbol

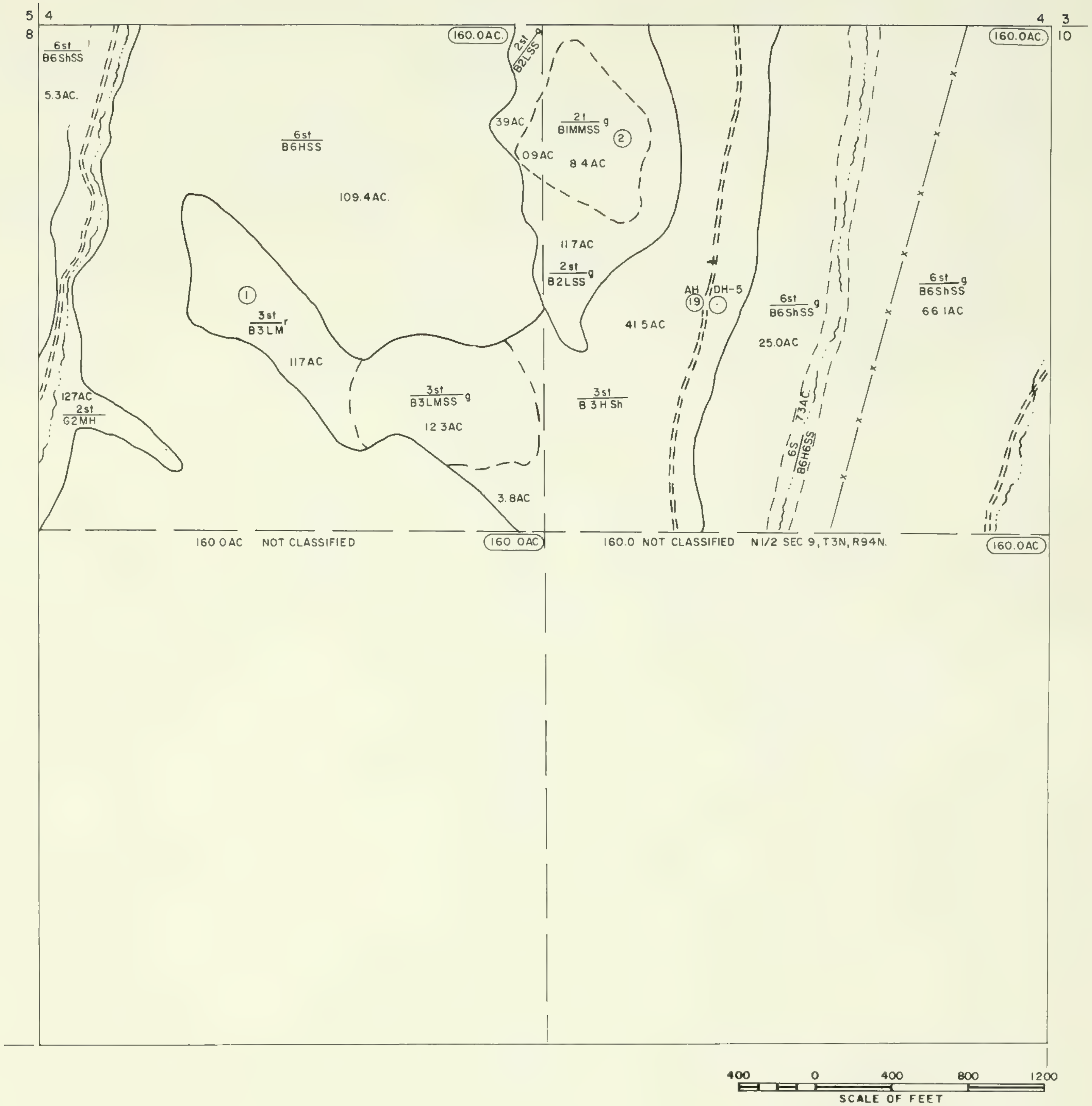
Soil Deficiency — Topography Deficiency
Land Suitability Class — Information Symbols
Land Use — Underlaying Geologic Material
Depth of Suitable Soil — Next Significant Soil Layer Texture
Surface Soil Texture

3 st / P3 LH Sh hw

Key to Laboratory Determination

Hydraulic Conductivity — fragment Samples
Settling Volume
Electrical conductivity of saturation extract — 0.2
5.5–6.4 — pH (CaCl2)
pH of 1:5





UNITED STATES
Department of the Interior
Bureau of Reclamation

COLLOM GULCH SITE EMRIA PROJECT

LAND CLASSIFICATION

Classified by JIBSON Planimetered by JIBSON

Date OCT. 1981 Photo No. CO77G 1-7-239

Sec. 9 T. 3N R. 94W

Salt Lake City, Utah

4th Section	1	2	3	Total	1	2	3	Total	Total Suitable	6	R.O.W.	Other	Grand Total
NE		20.1	41.5	61.6					61.6	98.4			160.0
NW		17.5	27.8	45.3					45.3	114.7			160.0
SW													
SE													
TOTAL		37.6	69.3	106.9					106.9	213.1			320.0

Symbols & Abbreviations most commonly used by U.S.B.R.

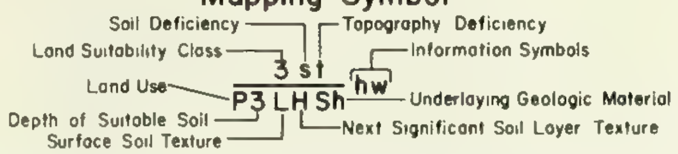
Soil Profile Symbols

- Cb Cobble
- Gr Gravel
- S Sand
- LS Loamy Sand
- SL Sandy Loam
- L Loam
- SiL Silt Loam
- SiCL Silty Clay Loam
- CL Clay Loam
- C Clay
- SiC Silty Clay
- HC Heavy Clay
- MS Mudstone
- Sh Shale
- SS Sandstone

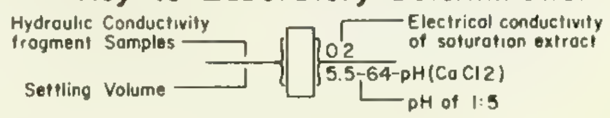
Land Use

- C – Irrigated cultivated
- P – Irrigated grassland
- L – Nonirrigated cultivated
- G – Nonirrigated grassland
- B – Brush or timber
- H – Suburban or homestead
- I – Idle

Mapping Symbol



Key to Laboratory Determination



1 (L / C / Sh)
3t / B2LMSh gzr
SAGEBRUSH, SERVICEBERRY
15 TO 30% SLOPE
WEATHERED SHALE BELOW 18"
LEDGE ROCK ON SURFACE

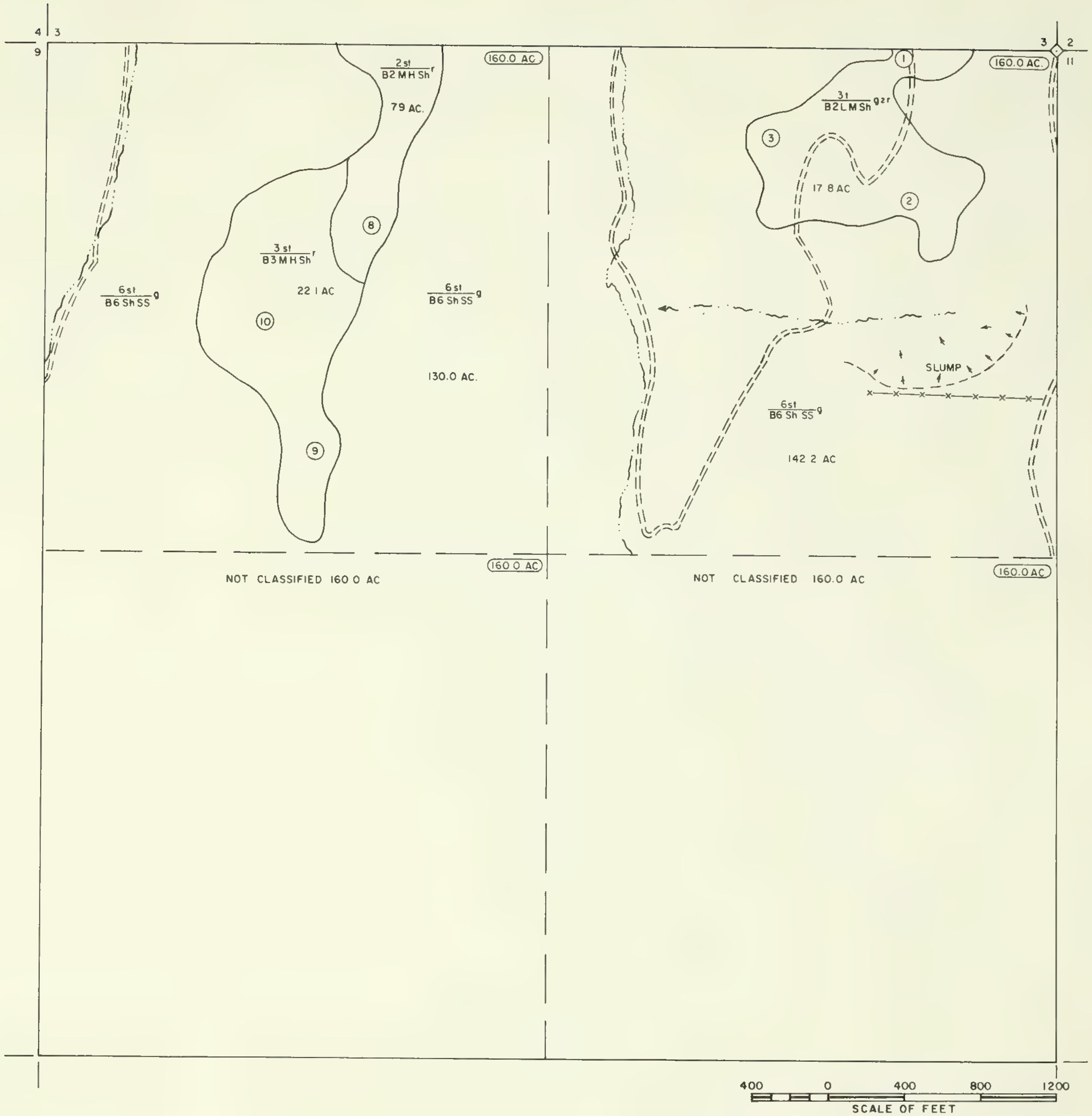
2 (L / O)
3t / B2LM gzr
SAGEBRUSH, SERVICEBERRY
24% SLOPE.
ROLLING REDDISH COLOR SOIL
FLOAT ROCK ON SURFACE

3 (L / SCL / O)
3t / B2LM gzr
SAGEBRUSH, SERVICEBERRY
25% SLOPE RIDGE TOP AND
SIDE SLOPE. FEW SCATTERED
SURFACE ROCK
REDDISH COLOR 24 TO 30"

8 (CL / C / SH)
2st / B2MHSh r
SERVICEBERRY, GRASSES
SAGEBRUSH
16% SLOPE TO WEST
SCATTERED SURFACE ROCK

9 (C / Δ / Sh)
3st / B3MHSh r
SERVICEBERRY, GRASSES
SAGEBRUSH
14% SLOPE TO WEST
SCATTERED SURFACE ROCK

10 (L / Sh)
3st / B3MHSh r
SERVICEBERRY, GRASSES
SAGEBRUSH
20% SLOPE TO WEST



4th Section	1	2	3	Total	1	2	3	Total	Total Suitable	6	R.O.W.	Other	Grand Total
NE			17.8	17.8					17.8	142.2			160.0
NW		7.9	22.1	30.0					30.0	130.0			160.0
SW													
SE													
TOTAL		7.9	39.9	47.8					47.8	272.2			320.0

UNITED STATES
Department of the Interior
Bureau of Reclamation

COLLOM GULCH SITE EMRIA PROJECT

LAND CLASSIFICATION

Classified by: JIBSON Planimetered by JIBSON

Date OCT 1981 Photo No. CO77G 1-7-240

Sec. 10 T. 3N R. 94W

Salt Lake City, Utah

Symbols & Abbreviations most commonly used by USBR

Soil Profile Symbols

Symbol	Meaning
Cb	Cobble
Gr	Gravel
S	Sand
LS	Loamy Sand
SL	Sandy Loam
L	Loam
SiL	Silt Loam
SiCL	Silty Clay Loam
CL	Clay Loam
C	Clay
SiC	Silty Clay
HC	Heavy Clay
MS	Mudstone
Sh	Shale
SS	Sandstone

Land Use

C – Irrigated cultivated
P – Irrigated grassland
L – Nonirrigated cultivated
G – Nonirrigated grassland
B – Brush or timber
H – Suburban or homestead
I – Idle

Mapping Symbol

3 st / P3 LH Sh, hw

Soil Deficiency; Topography Deficiency; Land Suitability Class; Information Symbols; Land Use; Underlaying Geologic Material; Depth of Suitable Soil; Next Significant Soil Layer Texture; Surface Soil Texture

Key to Laboratory Determination

Hydraulic Conductivity; fragment Samples; Settling Volume; 0 2 Electrical conductivity of saturation extract; 5 5-64-pH (CaCl2); pH of 1 5

1 — 1 / B1MH — CL, C, C, C — SAGEBRUSH & GRASSES; 8% SLOPE

2 — 3st / B3L SS — L, O — SAGEBRUSH & GRASSES; 15% SLOPE

3 — 2S / B2MH Sh — CL, C, O — SAGEBRUSH & GRASSES; 5% SLOPE; BROAD RIDGETOP

4 — 2S / B2MH Sh — CL, C, SH — SAGEBRUSH; 5% SLOPE

5 — 2S / B2MH Sh — C, C, O — SAGEBRUSH & GRASSES

6 — 2S / B2L M SS — L, CL, SS — SAGEBRUSH & GRASSES; 7% SLOPE; SIDESLOPE

7 — 2S / B2MH Sh — CL, C, SS — SAGEBRUSH; 3% SLOPE; BROAD RIDGETOP

8 — 2S / B2MH — CL, C, O — SAGEBRUSH & GRASSES; 3% SLOPE; BROAD RIDGETOP; STOPPED BY FLOAT ROCK

9 — 2S / B2MH SS — CL, SS — SAGEBRUSH & GRASSES; 3% SLOPE RIDGETOP

10 — 3st / B3M Sh — CL, SH, SH — SAGEBRUSH; 7 TO 10% SLOPE; SANDSTONE SURFACE ROCK

AH-2 — 3st / B3M Sh — 61, 27, 0, 04; CL, C, SH, SH; 78, 81, 85, 82 — SAGEBRUSH & GRASSES; 6 TO 7% SLOPE; RIDGETOP

AH-9 — 2S / B2MH Sh — 72, 42, 47, 32, 65, 05; C, C, C, SiC, SiC, SH; 84, 83, 84, 87, 4 34 / 84, 3 95 / 83 — SAGEBRUSH & GRASSES; RIDGETOP; 6% SLOPE

AH-10 — (TP-2) 2S / B2MH Sh — CL, C, C, SH; 82, 84, 81, 56 / 82, 92 / 82 — SAGEBRUSH & GRASSES; 3% SLOPE RIDGETOP

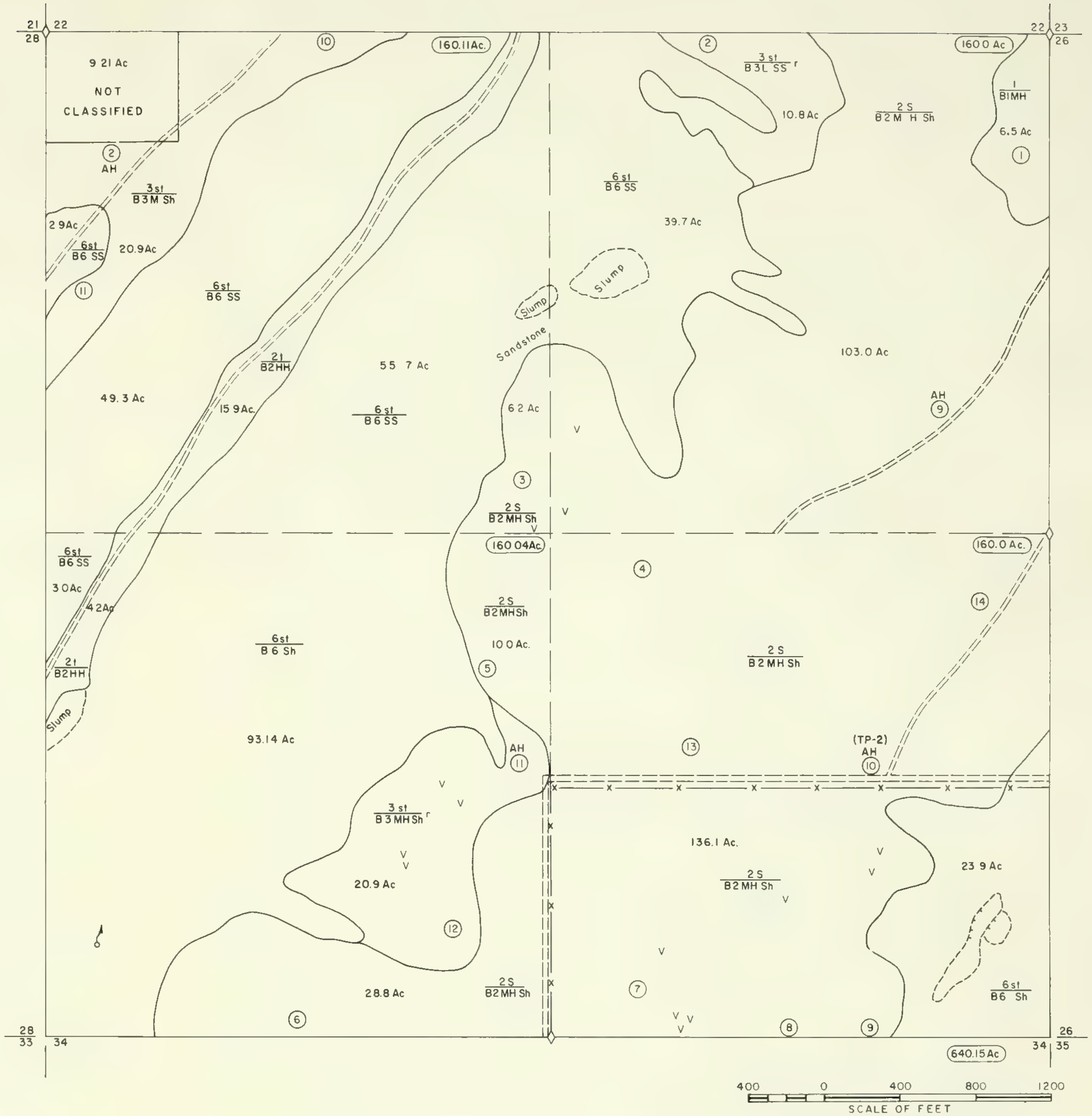
AH-11 — 3st / B3H Sh — 1 32, 27, 10; C, SH, SH; 78, 6 84 / 83, 7 50 / 87 — SAGEBRUSH & GRASSES; 5% SLOPE TO WEST

11 — 3st / B3M Sh — CL, SH, SH, SH — SAGEBRUSH; 25% SLOPE TO EAST

12 — 3st / B3M Sh — CL, C, SH, SS — SAGEBRUSH; 7% SLOPE; WEATHERED SHALE 18-24"

13 — 2S / B2M SS — L, SS, SS — SAGEBRUSH; 2-3% SLOPE; BROAD RIDGETOP; WEATHERED SANDSTONE 16-24"; 24 40" SURFACE ROCK

14 — 2S / B2MH Sh — CL, C, SH, SH, SS — SAGEBRUSH; 4% SLOPE; WEATHERED SHALE 16-24"; WEATHERED SANDSTONE 36-60"



4 th Section	1	2	3	Total	1	2	3	Total	Total Suitable	6	R O W	Other	Grand Total
NE	6 5	103 0	10 8	120 3					120 3	39 7			160 0
NW		22 1	20 9	43 0					43.0	107 9			150 9
SW		43 0	20 9	63 9					63 9	96 14			160 04
SE		136 1		136 1					136 1	23 9			160 0
TOTAL	6 5	304 2	52 6	363 3					363 3	267 64			630 94

UNITED STATES
Department of the Interior
Bureau of Reclamation

COLLOM GULCH SITE-EMRIA PROJECT

LAND CLASSIFICATION

Classified by J.R. Mc Coy Planimetered by J.K. JIBSON

Date Sept 19 81 Photo No C077G-1-5-161

Sec. 27 T. 4N. R. 94 W.

Salt Lake City, Utah

Symbols & Abbreviations most commonly used by U.S.B.R.

Soil Profile Symbols

- Cb — Cobble
- Gr — Gravel
- S — Sand
- LS — Loamy Sand
- SL — Sandy Loam
- L — Loam
- SiL — Silt Loam
- SiCL — Silty Clay Loam
- CL — Clay Loam
- C — Clay
- SiC — Silty Clay
- HC — Heavy Clay
- MS — Mudstone
- Sh — Shale
- SS — Sandstone

Land Use

- C — Irrigated cultivated
- P — Irrigated grassland
- L — Nonirrigated cultivated
- G — Nonirrigated grassland
- B — Brush or timber
- H — Suburban or homestead
- I — Idle

Mapping Symbol

3 st / P3 L H Sh hw

- Soil Deficiency
- Topography Deficiency
- Land Suitability Class
- Information Symbols
- Land Use
- Underlaying Geologic Material
- Depth of Suitable Soil
- Next Significant Soil Layer Texture
- Surface Soil Texture

Key to Laboratory Determination

- Hydraulic Conductivity fragment Samples
- Settling Volume
- 0.2 — Electrical conductivity of saturation extract
- 5.5-64 — pH (CaCl2)
- pH of 1:5

1 (CL, HC)
1 / G1MH
MEADOW GRASSES
3% SLOPE TO NORTH

2 (C)
1 / G1MH
MEADOW GRASSES
CANYON BOTTOMLANDS
3% SLOPE TO NORTH
VERY PERMEABLE CLAY

3 (C, SH)
3s / B3H Sh
SAGEBRUSH, OAK,
SERVICEBERRY
14% SLOPE

4 (HC, C)
2st / B2HHSh
SAGEBRUSH, GRASSES
10% SLOPE

5 (C, C, SH & SS)
2st / B2HHSh
SAGEBRUSH, GRASSES
16% SLOPE TO EAST

6 (HC, Δ)
2s / B2HH Sh
SAGEBRUSH, GRASSES
16% SLOPE TO EAST

7 (SL, SS)
6st / B6L SS
SAGEBRUSH, GRASSES
20% SLOPE TO EAST
SANDSTONE FLOAT ROCK

8 (C, Δ)
2st / B2HH Sh
SAGEBRUSH, GRASSES
SERVICEBERRY
14% SLOPE TO WEST

9 (C, Δ)
2st / B2HHSh
SAGEBRUSH, GRASSES
SERVICEBERRY
25% SLOPE
OLD SLUMP AREA

10 (C, SH)
2s / B1M2H6Sh
SAGEBRUSH, GRASSES
SERVICEBERRY
12% SLOPE

11 (SH)
3st / B3H Sh g
SERVICEBERRY, GRASSES
SAGEBRUSH
23% SLOPE
SHALE, SANDSTONE FLOAT
ROCK

12 (C, Δ)
3st / B3H Sh g
SERVICEBERRY, GRASSES
SAGEBRUSH
26% SLOPE WEST
STRONG SBK STRUCTURE

13 (C, C, SS)
3st / B2HHSS g
SAGEBRUSH, GRASSES
SERVICEBERRY
20% SLOPE WEST
SANDSTONE FLOAT ROCK

14 (C, SS)
3s / B3HSS
SAGEBRUSH, GRASSES
SERVICEBERRY
12% SLOPE EAST
SANDSTONE FLOAT ROCK

15 (SH)
6st / B6 Sh
GRASSES
SAGEBRUSH SERVICEBERRY
SHALE OUTCROPS TO SURFACE
28% SLOPE WEST

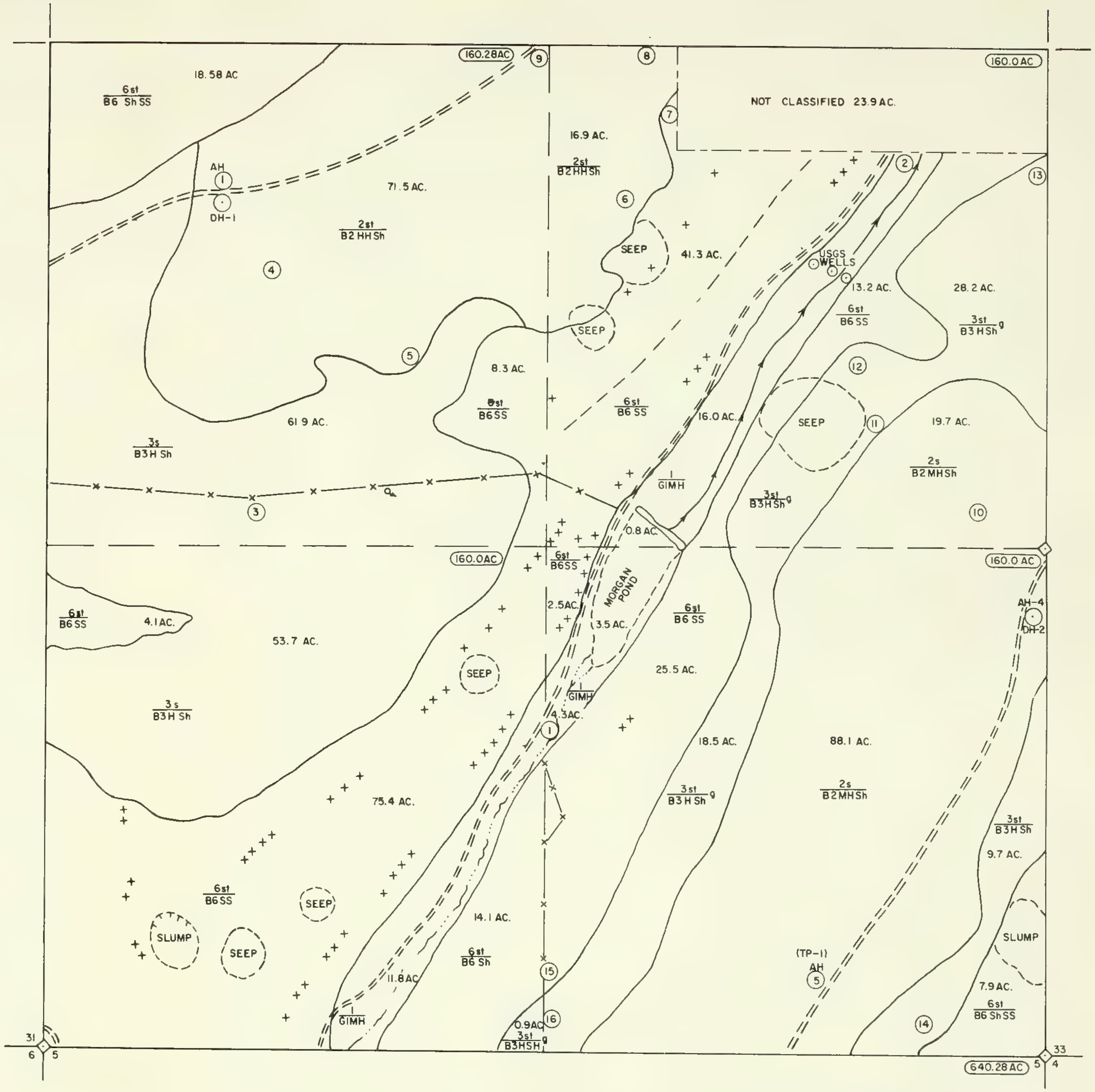
16 (C, SS)
3st / B3HSS
SERVICEBERRY, GRASSES
SAGEBRUSH
SANDSTONE FLOAT ROCK

AH-4 (CL, C, SH, SS) .842/8.4, .863/8.8, 10.4/8.1
(DH-2) 2s / B2MSh
SAGEBRUSH, GRASSES

DH-1 (L, CL, C, SH) .883/8.4, .494/8.8, .702/8.7, .753/8.3
2st / B2HHSh
SAGEBRUSH, GRASSES
5% SLOPE

AH-5 (CL, C, SiC, SH) .675/7.5, .51/7.5, .287/7.5, .326/7.3, .326/7.4
(TP-1) 2s / B2MHSh
SAGEBRUSH, GRASSES
5% SLOPE
RIDGETOP

AH-1 (L, CL, C, SH)
2st / B2HHSh
SAGEBRUSH, GRASSES, RUSSIAN
THISTLE
6% SLOPE BROAD RIDGETOP



4 th Section	1	2	3	Total	1	2	3	Total	Total Suitable	6	R.O.W	Other	Grand Total
NE	16.0	36.6	28.2						80.8	55.3			136.1
NW		71.5	61.9						133.4	26.88			160.28
SW	11.8		54.6						66.4	93.6			160.0
SE	4.3	88.1	28.2						120.6	39.4			160.0
TOTAL	32.1	196.2	172.9						401.2	215.18			616.38

UNITED STATES
Department of the Interior
Bureau of Reclamation

COLLOM GULCH SITE EMRIA PROJECT

LAND CLASSIFICATION

Classified by: JIBSON Planimetered by JIBSON

Date OCT 1981 Photo No. CO77G 1-6-196

Sec. 32 T. 4N. R. 94 W.

Salt Lake City, Utah

Symbols & Abbreviations most commonly used by U.S.B.R.

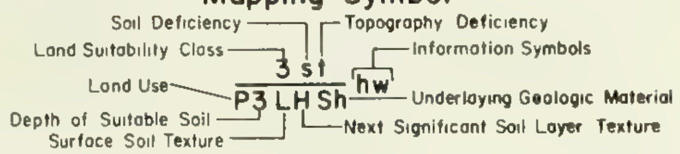
Soil Profile Symbols

Symbol	Meaning
Cb	Cobble
Gr	Gravel
S	Sand
LS	Loamy Sand
SL	Sandy Loam
L	Loam
SiL	Silt Loam
SiCL	Silty Clay Loam
CL	Clay Loam
C	Clay
SiC	Silty Clay
HC	Heavy Clay
MS	Mudstone
Sh	Shale
SS	Sandstone

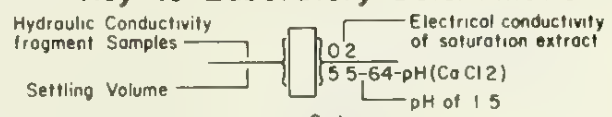
Land Use

C – Irrigated cultivated
P – Irrigated grassland
L – Nonirrigated cultivated
G – Nonirrigated grassland
B – Brush or timber
H – Suburban or homestead
I – Idle

Mapping Symbol



Key to Laboratory Determination



1 — $\frac{6st}{B6LSS}$ — SS
SAGEBRUSH & NATIVE GRASSES
15% SLOPE

AH-15 — $\frac{2st}{B2MHSh}$ g — SiCL .15 / 7.2; C .03 / 7.5; SH .05 / 8.5; SH .32 / 8.2; SS .15 / 8.3
SAGEBRUSH & NATIVE GRASSES
12% SLOPE TO NORTH

2 — $\frac{3st}{B3LSS}$ — L, SS
SAGEBRUSH & NATIVE GRASSES
10% SLOPE

3 — $\frac{2st}{B2MHSh}$ — CL, C, Sh
SAGEBRUSH & NATIVE GRASSES
12% SLOPE

AH-16 — $\frac{B2st}{B2LHSh}$ g — L 1.68 / 6.9; C .39 / 7.4; SH .02 / 8.6; SH .03 / 8.3; SH .18 / 8.6; SS .45 / 8.7
SAGEBRUSH & NATIVE GRASSES
13% SLOPE

4 — $\frac{3st}{B3L}$ r — L, △
SAGEBRUSH
LEDGE & SURFACE FLOAT ROCK
17% SLOPE

5 — $\frac{2st}{B2LMSh}$ — L, CL, C, Sh
SAGEBRUSH
15% SLOPE

USGS — $\frac{2S}{B2MH}$ — C, SiC, SiC, SiC, SiC
OBSERVATION WELL
2% SLOPE
GRASSES

6 — $\frac{3st}{B3MHSh}$ — CL, C, Sh
SAGEBRUSH
21% SLOPE

7 — $\frac{3st}{B3MHSh}$ — CL, C, SH
SAGEBRUSH, SERVICEBERRY
11% SLOPE

8 — $\frac{3st}{B3MHMS}$ — CL, C, SH, MS
SAGEBRUSH
7% SLOPE

10 — $\frac{2st}{B2LHSS}$ g — L, CL, C, SS, SS
SASEBRUSH, GRASSES
5% SLOPE
24"-30" WEATHERED SANDSTONE

AH-3 — $\frac{2S}{B2HSh}$ — C; SH 2.5 / 8.3; SH 2.7 / 8.2; SS 20 / 8.9
SAGEBRUSH, GRASSES
1.5% SLOPE

11 — $\frac{3st}{B2HHSS}$ g — C .20 / 7.8; C .17 / 7.9; C .18 / 7.8; △
SAGEBRUSH, GRASSES
18-20% SLOPE
SURFACE ROCK

9 — $\frac{3st}{B2MHSS}$ g — CL, C, SS
SAGEBRUSH, GRASSES
17% SLOPE

12 — $\frac{2S}{B2MHSh}$ — CL, C, C, SH, SS
SAGEBRUSH, GRASSES
4% SLOPE

4th Section	1	2	3	Total	1	2	3	Total	Total Suitable	6	R.O.W.	Other	Grand Total
NE		19.8	40.6	60.4					60.4	99.6			160.0
NW		56.4	56.3	112.7					112.7	38.6			151.3
SW		15.3	19.0	34.3					34.3	125.7			160.0
SE		52.0	51.6	103.6					103.6	56.4			160.0
TOTAL		143.5	167.5	311.0					311.0	320.3			631.3

UNITED STATES
Department of the Interior
Bureau of Reclamation

COLLOM GULCH SITE EMRIA PROJECT
LAND CLASSIFICATION

Classified by: MC COY   Planimetered by JIBSON
Date OCT. 1981   Photo No OC77G 1-6-196

Sec. 33 T. 4 N. R. 94 W.
Salt Lake City, Utah

Symbols & Abbreviations most commonly used by U.S.B.R.

Soil Profile Symbols

Cb	Cobble
Gr	Gravel
S	Sand
LS	Loamy Sand
SL	Sandy Loam
L	Loam
SiL	Silt Loam
SiCL	Silty Clay Loam
CL	Clay Loam
C	Clay
SiC	Silty Clay
HC	Heavy Clay
MS	Mudstone
Sh	Shale
SS	Sandstone

Land Use

C – Irrigated cultivated
P – Irrigated grassland
L – Nonirrigated cultivated
G – Nonirrigated grassland
B – Brush or timber
H – Suburban or homestead
I – Idle

Mapping Symbol

3 st hw / P3 L H Sh

Soil Deficiency
Topography Deficiency
Land Suitability Class
Information Symbols
Land Use
Underlaying Geologic Material
Depth of Suitable Soil
Next Significant Soil Layer Texture
Surface Soil Texture

Key to Laboratory Determination

0.2 / 5.5-64-pH(CaCl2)

Hydraulic Conductivity fragment Samples
Settling Volume
Electrical conductivity of saturation extract
pH of 1:5

1 — 2s / BIL 2H — CL, C, Δ
VEG. SAGEBRUSH
NATIVE GRASSES
STOPPED AT 30" FLOAT ROCK

2 — 2s / B 2 M H SS — L, C, SS
VEG. SAGEBRUSH
NATIVE GRASSES
TOPOG. 7% SLOPE

3 — 2s / B2 L M SS — L, C, C, SS
VEG. SAGEBRUSH-GRASSES
6% SLOPE.

4 — 3 st / B3 M H Sh — C, C, SH
VEG. SAGEBRUSH GRASSES
RAW SHALE BELOW 20"

5 — 6st / B6 Sh — SH
VEG. SAGEBRUSH

6 — 2s / B MM Sh r — S C L, SH
VEG. SAGEBRUSH
LARGE ROCKS ON SURFACE

7 — 6st / B6 H Sh — SH, SH, SH
VEG SAGEBRUSH
TOPOG. STEEP SIDESLOPE

8 — 6st / B6 Sh — COAL
COAL SEAM EXPOSED ON
HILLSIDE

9 — 6st / B6 M Sh — SH, MS
VEG. SAGEBRUSH
GRASSES

10 — 2s / B2 L M SS — L, CL, C, Δ
VEG. SAGEBRUSH GRASSES

DH-3 — 2s / B 2 L M Sh — L (0.5 / 8.1), SCL (0.37 / 8.5), C (0.34 / 8.5), C (0.27 / 8.6), SH
SAGEBRUSH, GRASSES
5% SLOPE

AH-12 — 2s / B2 M M Sh — SC CL, SCL, SH, SH
SAGEBRUSH, GRASSES
5% SLOPE

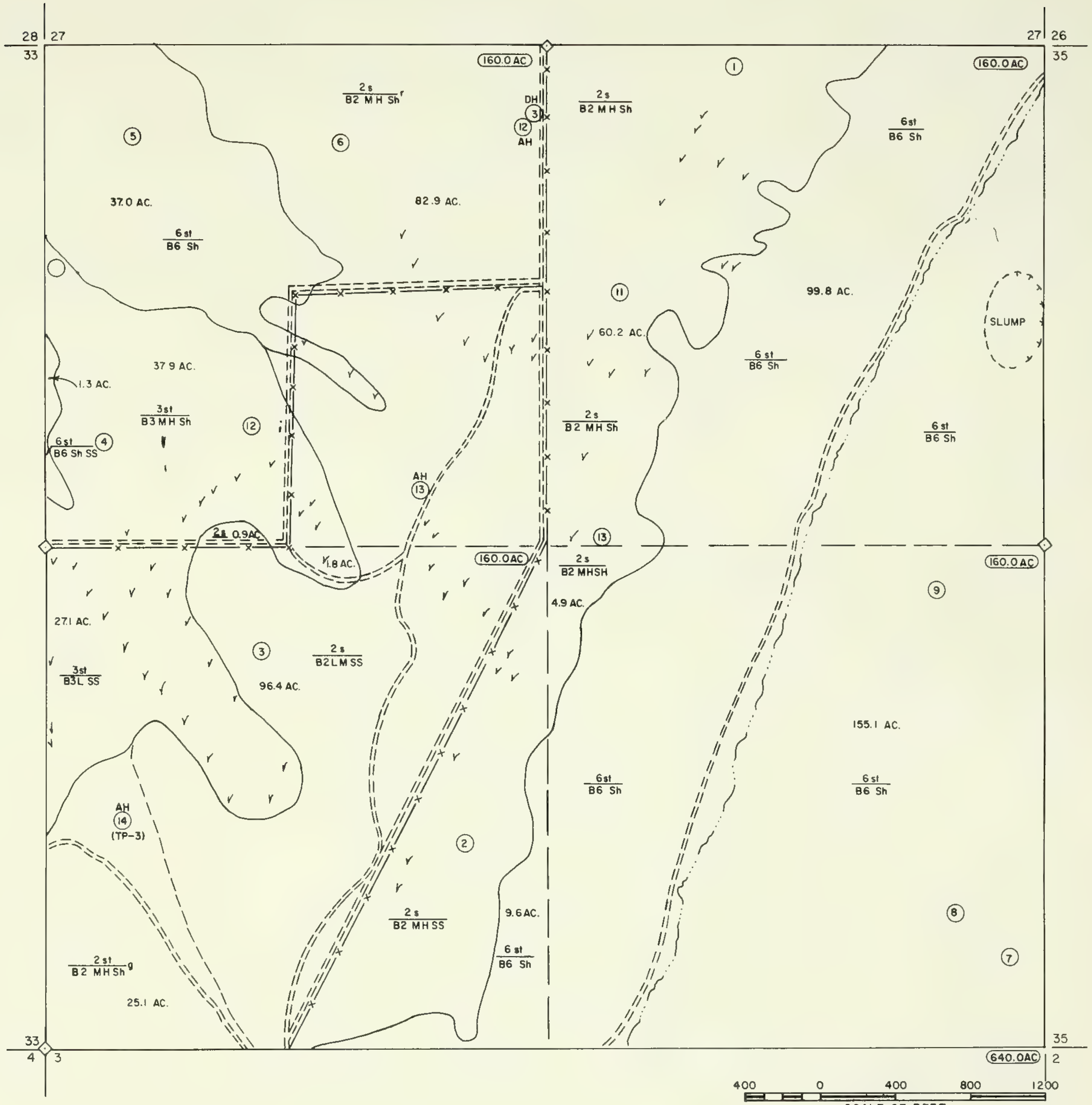
AH-13 — 2s / B 2 M Sh — .66 C 8.5, .26 SH 8.9, .02 SH 9.1
SAGEBRUSH, GRASSES,
RABBITBRUSH
8% SLOPE TO NW

AH-14 — 2 st / B2 M H Sh r — C, SH, SS
SAGEBRUSH, NATIVE GRASSES
8% SLOPE

11 — 3s / B3 L M r — L, CL, SS
SAGEBRUSH
SLOPE 8% GENTLY ROLLING
LEDGE ROCK SANDSTONE
STONY SURFACE SANDSTONE
BELOW 15"

12 — 3 st / B3L M Sh r — L, C, Sh, SS
SAGEBRUSH WITH OAKBRUSH
CLUMPS-SURFACE ROCK
DARK SHALE 10 - 18"
GRAY SHALE 18 - 48" HIGH LIME
RUST WEATHERED SANDSTONE 48 - 60"

13 — 2s / B2 L M SS — L, CL, SS
SAGEBRUSH
SLOPE 6 -8% GENTLY ROLLING
STONY RIDGE TOP
STOPPED BY SANDSTONE 12+"



UNITED STATES
Department of the Interior
Bureau of Reclamation

COLLOM GULCH SITE EMRIA PROJECT

LAND CLASSIFICATION

Classified by: JIBSON Planimetered by JIBSON
Date OCT 1981 Photo No. CO77G-1-6-195

Sec. 34 T. 4N. R. 94 W.
Salt Lake City, Utah

4 th Section	1	2	3	Total	1	2	3	Total	Total Suitable	6	R.O.W.	Other	Grand Total
NE		60.2		60.2					60.2	99.8			160.0
NW		83.8	37.9	121.7					121.7	38.3			160.0
SW		121.5	28.9	150.4					150.4	9.6			160.0
SE		4.9		4.9					4.9	155.1			160.0
TOTAL		270.4	66.8	337.2					337.2	302.8			640.0

APPENDIX D

GREENHOUSE STUDIES

Final Report on the
Greenhouse Studies for
Collom Gulch, Colo.

Submitted by

E&A Environmental Consultants, Inc.
1613 Central Street
P.O. Box 372
Stoughton, MA 02072

Contract No. 1-07-DV-00124
Characterization of Soil and Overburden Material

April 27, 1983

SECTION I

INTRODUCTION

Increased coal production, as a result of dwindling oil resources as well as the reliable availability of foreign oil, will result in the need to reclaim millions of acres. In addition to coal mining, the extraction of other minerals and elements will result in additional acreage necessitating revegetation. Schuman et al. (1976) estimated that over 6.4 million acres of land will need revegetation annually.

There are vast regional differences where mining occurs. Reclamation of coal land in the Northern Great Plains will be significantly different than in the Southwest or Central Plains. Soils, climate, water resources, hydrogeological conditions, and other edaphic factors play a major role in the revegetation process. The two major aspects of the revegetation process that lend themselves to management and/or manipulation in order to achieve proper revegetation are soils and plants.

There are numerous soil characteristics which will affect the revegetation process. These can be characterized as soil chemical, soil physical, and biological.

The soil chemical properties generally affect the availability of macronutrient, micronutrient, and consequently the potential growth of plants. The effects can be either beneficial or result in phytotoxic effects.

The soil or overburden material in the Northern Great Plains is characteristically alkaline (pH 7 or greater) and may have an undesirably high level of salts. The calcareous material contains predominantly soluble calcium, magnesium, and sodium sulfate salts.

Soil fertility is another major factor in species establishment during revegetation. Soils of the Northern Great Plains are deficient in plant-available phosphorus and, for adequate growth, need the addition of 50 to 100 pounds of fertilizer P (Power et al., 1978).

Plant available nitrogen is also a problem in this area. Although shales of the Fort Union Formation contain exchangeable ammonia (Power et al., 1974), this ammonia may become lost through nitrification and removal, thus requiring the addition of nitrogen for revegetation. Potassium has generally not been found to be deficient (Power et al., 1978).

The availability of nutrients for proper revegetation can usually be corrected by adequate fertilization. Phytotoxic effects of salts and micronutrients (heavy metals) represent a more difficult management aspect.

One aspect in the use and management of mined lands is the availability and toxicity of heavy metals to plants and animals and the potential movement of these heavy metals into ground and surface waters.

The heavy metal cycle is illustrated in Figure 1. Heavy metals in the soil can undergo many reactions, including adsorption which includes both chemical and physical forces; ion exchange; retention or immobilization, e.g., by phosphorus; complexation; and chelation, i.e., retention by organic matter and solubilization. These reactions determine the availability of the metals to plants, water resources, and human and animal food chains. Accumulation in the plant can result in phytotoxicity and the destruction of the plant or reduced growth and crop yields. Several metals accumulate in the plant; and, even at very high levels, there is no indication of phytotoxicity, but their accumulation can result in toxic levels to humans or animals.

Plant uptake of heavy metals is the major mode of accumulation; however, in western mine areas dustfall on the plant can also be important. Direct ingestion by grazing animals can also be an important method by which metals enter the animal and human food chains. Other major potential contamination sources are through erosion, surface water, and ground water contamination.

There are many factors that affect the accumulation of heavy metals in plants. Table 1 lists these factors.

Table 1
Factors affecting the accumulation of heavy metals in plants

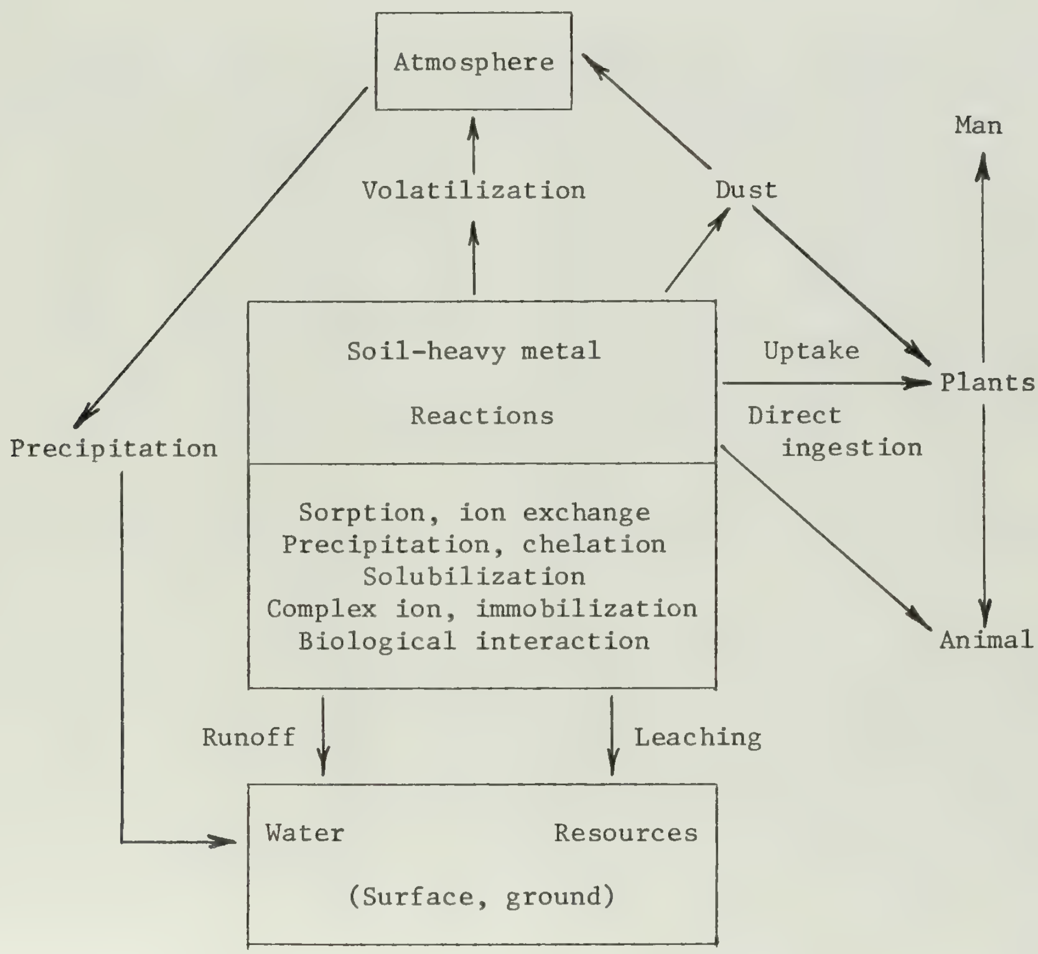
Soil factors
1. pH
2. Organic matter
3. Cation exchange capacity
4. Soil physical properties--temperature, moisture, and aeration
5. Factors affecting immobilization, reversion, and retention
6. Distribution throughout the soil matrix

Chemical factors
1. Interaction of various metals
2. Phosphate availability
3. Competing ions
4. Chemical state of the ion

Plant factors
1. Rooting depth
2. Plant age
3. Plant species and varieties
4. Plant organs--leaf vs. root vs. fruit

In a previous literature review which was part of this project, concentration was on the essentiality and toxicity of plants and animals of several heavy metals which are predominant in western coal mine areas.

Figure 1
The heavy metal cycle in the environment



A summary of these data is shown in Table 2. The essentiality or toxicity of a given element often varies considerably depending on the plant species or varieties and the animal species. It is difficult, therefore, to provide exact levels or even ranges which impact plants and animals. Thus Table 2 provides the reader with the general summary of the data found in the literature.

Soil physical properties affecting plant growth and development are also important in the management of mined areas. Probably the most important aspect is the soil-water-plant relationships. The water retention and transmission characteristics will be generally affected by the management of overburden material. In addition the interaction of soil chemical characteristics and soil physical properties will affect plant growth.

Although the total soluble salt concentration (EC) may not present a problem in some cases, the high exchangeable sodium can result in poor soil physical characteristics. In addition to the effect on surface sealing and infiltration, sodium salts affect the osmotic potential (Epstein, 1973), which results in reduced water uptake and utilization by plants. Since efficient water use is an extremely important factor in good revegetation, the effect of salts, and particularly sodium, is important. Data by Sandoval et al. (1973) show considerable variability in the concentration of sodium, calcium, magnesium, sulfate, and sodium adsorption ratio in the Northern Great Plains surface mine spoils. There are several techniques which can be used to alleviate high salt problems. The uses of gypsum ($CaSO_4$) as a soil conditioner and for high salt leaching are but two techniques (Power et al., 1975; Doering and Willis, 1975).

Soil management techniques involving organic matter additions, crop selection, and soil manipulation can assist greatly in the establishment and maintenance of vegetation.

Another major aspect of revegetation is the selection of the proper species. The adaption of vegetation to the mined area depends on many factors; such as elevation, salt tolerance, drought resistance, and winter hardiness. Another consideration is the palatability and nutrition of the plants for livestock and wildlife. The use of native grasses vs. introduced species is often dependent on the availability of seed. Power et al. (1978) indicates that native grasses of wheatgrass, needlegrass, and grama species are adapted to the soils and climate of the Northern Great Plains. Lang et al. (1975) issued guidelines for seeding dryland range, pasture, and disturbed lands in Wyoming. One of the plants which has been used successfully over a wide range of conditions is crested wheatgrass (Shuman et al., 1976).

The objectives of this study are listed below.

1. Characterize soil and overburden material provided by the Bureau of Reclamation, U.S. Department of Interior, with respect to soil chemical characteristics.

Table 2
The essentiality and toxicity of several heavy metals
predominant in western coal mine areas
(Units--parts per million)1/

Metal	General concentration in soils	Plant		Animal	
		Essentiality	Toxicity	Essentiality	Toxicity
Arsenic	5 - 13	NE	NT	NE	T2/
Boron	20 - 700	E, <0.5- 1	>1	NE	<150
Cadmium	1 - 10	NE	NT	NE	T2/
Copper	1 - 300	E,<5, 1 - 50	T, >20	E2/	>15
Iron	0.15 - 103/	E, <20 - 100	T2/	E, 20 -100	T 500-3,000
Lead	2.6 - 25	NE	T, <350	NE	T, <1,000
Manganese	2 -20,000	E, <20	T, 400- 500	E 5 - 60	T <1,000
Molybdenum	3 - 8	E, <0.1	T >1,000	E2/	T2/
Nickel	3 - 300	E2/	T, 20- 50	E2/	T >700
Selenium	0.001- 3.4	E, 30 -1,000	T, 30-1,000	E 0.1- 0.3	T > 5
Zinc	10 - 2,000	E, <25	T2/	E, 40 -100	T >1,000

1/ Except where noted.
2/ Values are highly variable depending on plant or animal.
3/ Percent.

NE = nonessential; E = essential; NT = nontoxic; T = toxic.

2. Conduct greenhouse studies on these materials to determine uptake of elements and to observe phytotoxic effects.

3. To determine changes in soil chemical characteristics which may have occurred during the growing season.

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SECTION II

ANALYTIC PROTOCOLS

Procedures

All field sampling of soils and overburden material was conducted by the Bureau of Reclamation. The amount of soil or geological material varied and in several cases the quantities were too small to conduct multiple replicate experiments.

Greenhouse Procedures

The soil materials were placed in 10-inch plastic pots where possible. Smaller 6- or 8-inch pots were used when low quantities of material were available. Whenever possible, replicated samples of each soil were seeded to Barley var. Steptoe. This variety was obtained from the USDA High Plains Grassland Research Station in Cheyenne, Wyo. Prior to seeding, the soil received nitrogen (N) and phosphorus (P) fertilizer at a rate of 60 lbs/acre N as ammonium nitrate and 80 lbs/acre of P as triple phosphate. In some cases nitrogen deficiencies occurred during the growth cycle necessitating the addition of a complete fertilizer.

Each pot was packed with a uniform amount of soil at approximate field capacity. Initially, pots were seeded to 35 seeds per pot; however, poor germination as a result of poor surface conditions and excessive surface drying necessitated a higher seeding rate. The pots were then seeded with 100 seeds and covered to maintain humid conditions favorable for germination. The pots were watered three times per week with 100 milliliters (ml) of water or more to avoid excessive leaching of salts.

The plants were grown for a 60-day growth cycle before harvesting. At harvest, dry weights of plants were taken.

Plant Analysis

The fresh sample is ovendried at 60° C for a minimum of 48 hours. Approximately 2 grams of the dried material are ground in a Wiley Mill through a 20-mesh screen.

Five-tenths gram is measured into a porcelain crucible, and the sample is ashed in a muffle furnace for 12 hours at 500° C.

Five ml of concentrated hydrochloric acid (HCL) are added to the ashed sample. After 20 minutes the sample is washed into a 25-ml volumetric flask and brought up to volume with 1 N HCL.

The concentrations of the following 15 elements are determined with the ICAP emission spectrophotometer, Jarrell-Ash Model 955.

Macronutrients	phosphorus, potassium, calcium, magnesium
Micronutrients	zinc, boron, manganese, molybdenum, iron, copper, sodium
Heavy metals	cadmium, lead, arsenic, aluminum

Laboratory Analysis

The following extraction procedure was used for plant available phosphorus, potassium, zinc, iron, copper, and manganese.

The extracting solution was a 10 percent solution of sodium acetate in 3 percent acetic acid at a pH of 4.8. Five (5) grams of soil which had been screened through a 12-mesh screen were extracted with 15 ml of the extracting solution. The soil-extractant was shaken for 20 minutes using a wrist action shaker at 150 oscillations per minute. After 1 minute of settling, the solution was filtered through a Whitman No. 2 filter. Ten (10) ml of the filtrate were analyzed by an inductively coupled argon plasma spectrophotometer (ICAP).

Diethylenetriamin Pentacetic Acid (DTPA)

Plant available cadmium, nickel, and lead were extracted with diethylenetriamin pentacetic acid (DTPA). The solution extractions were analyzed by ICAP for cadmium and lead, and atomic adsorption spectrophotometry was used for nickel.

SECTION III

STATISTICAL ANALYSIS

Introduction

This section presents the data and statistical analysis for the 300 series. These samples were obtained from the Collom Gulch, Colo. site.

Table 3 identified these Reclamation samples with respect to E&A Environmental Consultants', Inc. laboratory numbers.

Soil Analyses Data

Preplant analysis

Tables 4, 5, and 6 show the preplant available, preplant total, and DTPA soil analyses for each of the samples. The statistical summaries are shown in Tables 7 and 8. The means and ranges were within expected norms with the exception of arsenic in the preplant total analysis.

The only element which could be phytotoxic at the levels found in the soil is boron. Boron toxicity can be phytotoxic to sensitive plants at concentrations exceeding 1 part per million (ppm).

Postharvest analysis

The postharvest soil analysis data are presented in Tables 9 (available), 10 (DTPA), and 11 (total). The statistical summaries are shown in Tables 12 and 13. Means and ranges for all the elements except arsenic were within expected norms with no indication of potential phytotoxicity.

Plant tissue analysis

The plant tissue data are shown in Table 14. The statistical analyses are shown in Table 15. All elements were within expected ranges. Although some soils had high boron levels, the plant tissue did not indicate levels which may be toxic to animals.

Tables 16 and 17 indicate the correlation coefficients between plant dry weight and the preplant and postharvest available and total soil analysis, respectively. All the correlations were poor. Table 18 shows the correlation between dry weight of plants and tissue analysis. Again all correlations were poor.

Table 3
Sample numbers and laboratory identification numbers for the 300 series

Bureau of Reclamation number	Depth (feet)	E&A[1/] laboratory number	Bureau of Reclamation number	Depth (feet)	E&A[1/] laboratory number
DH-1	0 - 0.5	301	DH-4	14.5 - 40.1	330
DH-1	0.5- 2	302	DH-4	101 -108	331
DH-1	18.7- 27	303	DH-4	116.6 -130.4	332
DH-1	2 - 3.5	304	DH-4	76.6 - 81.3	333
DH-1	3.5- 6	305	DH-4	183.6 -187.9	334
DH-1	88 -105.4	306	DH-5	0 - 1	335
DH-1	134.9-141.7	307	DH-5	1 - 2	336
DH-1	251.1-273.1	308	DH-5	2 - 5	337
DH-2	0 - .5	309	DH-5	5 - 9	338
DH-2	0.5- 3	310	DH-5	258.2 -285.7	339
DH-2	24.1- 29.9	311	DH-5	249.1 -258.2	340
DH-2	31.5- 47.3	312	DH-5	73.6 - 86.7	341
DH-2	3 - 5	313	DH-5	199.2 -208.1	343
DH-2	5 - 7	314	TP-1	0 - .25	344
DH-2	157 -164.5	315	TP-1	2.1 - 2.9	345
DH-2	287.4-296.9	316	TP-1	.9 - 2.1	346
DH-2	305.7-311.5	317	TP-1	.25- .9	347
DH-3	0 - 1	318	TP-1	2.9 - 6.0	348
DH-3	1 - 2	319	TP-2	0 - .3	349
DH-3	2 - 4	320	TP-2	1.2 - 2.6	350
DH-3	48.7- 59.5	321	TP-2	2.6 - 6.0	351
DH-3	62.2- 76.4	322	TP-2	.3 - 1.2	352
DH-3	93.8-106.3	323	TP-3	0 - .2	353
DH-3	298.3-306.1	324	TP-3	.2 - .6	354
DH-3	235.6-245.5	325	TP-3	.6 - 1.2	355
DH-4	0 - 1	326	TP-3	1.2 - 2.2	356
DH-4	1 - 2	327	Control bottom layer		357
DH-4	2 - 4	328	Control bottom layer		358
DH-4	4 - 6	329			

1/ E&A Environmental Consultants, Inc.

Table 4
300 series preplant soil analysis available

	Soil pH	Cation exchange capacity	Phosphorus	Potassium	Zinc	Copper	Manganese
			Unit--parts per million				
1	6.9	15.7	4	166	0.6	0.1	14
2	8	23.4	0	48	.5		16
3	7	32.1		113	7.4		59
4	8.2	32.6		55	.9		14
5	7.9	34		81	1.2		42
6	8.4	11.5		30	.8	.1	7.8
7	7.7	18.5		119	7.5	.2	37
8	8.4	11.2	0	29	.9	.1	34
9	7.4	15.5	5	204	.4		11
10	8.4	26.9	0	46	.2		11
11	7.7	27.4	1	103	1.2		117
12	8.4	18.4	0	100	3.8		30
13	8.3	31.6	6	45	1.3		33
14	7.6	15	0	29	1	.1	74
15	8.2	17		130	6.3	.2	55
16	8.6	11.4		74	3.3	.1	29
17	8	14.2	0	165	8	.2	27
18	7.3	12.2	8	124	0.9	.1	9.2
19	7.1	10.3	1	29	.4	.1	5.7
20	7.5	12.4	1	23	.3	.1	3.4
21	7.9	17.1	0	100	9.8	.6	11
22	7.8	15.2		99	6.5	.3	8.1
23	8.1	10		27	1.9	.1	10
24	8.1	3.5		28	1.9	.1	5.6
25	7.8	5.9	0	130	9.4	.5	3
26	7.2	13.8	4	103	.2	.1	10
27	7.7	13.7	0	29	.2		10
28	8.3	14		16	.5		14
29	8.7	15.3		11	.4		9.6
30	8.8	9.9		12	1	.1	12
31	8	15.2		120	10	.5	39
32	8.5	11.5		70	5.2	.7	30
33	7.1	13.9		110	17	1.6	2
34	6.6	13.7	0	134	9.1	.5	6.3
35	6.7	13.4	2	107	.7	.1	14
36	8	18.3	0	26	.6		2.9
37	7.4	22.2	2	26	1.3		.4
38	7.5	21.3	9	29	1.9		.4
39	7.8	5.3	0	26	2.4	.1	13
40	7.9	8.9		69	10	.8	11
41	8.4	12.2		50	9.8	1	52
42	6.3	12.6		78	11	0.6	4.5
43	6	17.4	0	96	8.2	.4	9.7
44	6.7	15	2	108	.2	.1	8
45	8	18.3	0	16	.1		45
46	7.9	16.1	0	23	.2		26
47	7.4	15.4	1	43	.1		11
48	8.4	19.8	0	19	.9		53
49	7.5	14.9	6	105	.5		25
50	8	16.5	0	24	.1		9.9
51	8.3	20	0	18	1.6		20
52	7.6	14.7	1	32	.1		27
53	7.2	13.2	8	167	.6		11
54	7.3	13.6	1	144	.2		17
55	7.3	15.2	0	108	.1		16
56	7.6	14.5	0	44	.1		13
57	7.7	16.1	25	510	.2		3.6
58	7.8	15.7	18	373	.3	.1	5.7

Table 5
300 series preplant soil analysis total
(Unit--parts per million)

	Phosphorus (P)	Potassium (K)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Zinc (Zn)	Boron (B)	Manganese (Mn)	Molybdenum (Mo)	Copper (Cu)	Iron (Fe)	Cadmium (Cd)	Lead (Pb)
1	398.9	3,100	2,770	2,916	143.1	7.17	1.08	514.8	0	1.65	8,973	0.41	0
2	288.7	3,629	9,036	6,595	208.6	76.26	8.49	423.3		20.55	8,988	.53	
3	280.3	2,445	9,097	6,706	241.6	102.5	7.36	343.9		24.72	8,980	.63	
4	294.8	2,708	9,019	7,264	243.5	77.99	6.73	403.5		22.11	9,001	.53	
5	200.5	5,561	8,993	8,043	696.4	99.96	8.04	323.9		25.57	9,005	.55	
6	304.1	1,006	9,136	6,968	86.9	30.45	5.12	173.2		2.83	8,148	.12	
7	256.3	3,823	9,086	6,487	257.8	98.96	7.13	376.6		25.52	8,997	.68	
8	335.9	961.4	9,117	8,161	86.2	7.13	4.26	182.3		3.44	5,241	.02	
9	410.4	5,257	2,821	3,789	267.2	73.35	14.56	527.9		17.97	8,992	.46	
10	256.3	4,796	9,041	6,753	491.1	72.23	9.22	367.1		18.09	9,004	.42	
11	319.9	4,704	3,955	4,739	315.4	87.43	9.63	592.1		16.08	9,004	.55	
12	346.2	3,101	8,995	9,982	239.4	58.86	7.39	297.2		54.34	9,016	.32	
13	351.3	4,917	8,875	11,080	1,125	83.86	6.79	410.5		20.82	8,995	.33	
14	360	2,009	8,934	10,330	339.6	37.74	6.78	343.7		6.14	9,007	.25	
15	419.7	5,239	8,808	11,080	337.2	102.6	8.89	544.5		23.01	8,990	.55	
16	422.1	2,324	8,890	11,070	193.2	48.32	10.29	429.5		10.77	8,996	.27	
17	228.1	5,198	8,975	7,703	417.3	102.4	8.26	371.1		21.6	9,004	.64	
18	522.9	3,517	2,816	2,176	192.3	74.14	11.16	505.2		15.06	8,989	.42	
19	407.1	3,068	2,152	1,986	196.1	64.39	10.44	364.5		12.53	8,991	.35	
20	387.7	2,594	2,974	1,874	166.5	56.92	9.15	239.5		8.34	9,007	.26	
21	345.2	2,832	9,134	5,083	286.2	76.74	2.56	129.4		17.99	6,327	.44	
22	406	3,178	7,225	4,838	310.8	83.89	7.43	448.2		17.85	8,992	.4	
23	295.6	737.2	9,101	8,514	117.8	28.21	3.53	291.6		3.46	6,569	.2	
24	524.3	5,269	3,118	1,601	1,406	97.67	2.42	81.51		18.14	5,534	.71	
25	294.4	380.4	9,177	6,670	60.8	18.99	2.86	114.5		2.01	5,968	.08	
26	338.6	3,902	3,214	2,297	216.4	62.9	8.28	477.8		12.77	8,989	.33	
27	243.1	3,393	8,130	2,743	205.8	59.48	7.52	460.7		11.49	8,990	.3	
28	311.7	2,231	8,994	5,045	183.2	50.78	4.14	330		9.94	9,016	.28	
29	282.8	1,685	8,925	7,550	163.7	35.8	4.27	253		6.17	8,066	.22	
30	240.7	1,191	8,965	3,655	97.8	29.51	3.52	143.9		2.08	4,862	.09	
31	362	5,891	8,916	9,570	400.1	101.6	5.3	511		28.82	8,998	.54	
32	524.1	2,951	8,866	11,050	249.1	49.58	7.48	405.3		10.02	8,993	.28	
33	71.16	5,654	2,208	2,165	377.6	119.5	2.19	24.91		20.84	3,925	.7	
34	82.3	5,887	3,706	2,976	393.4	97.84	3.61	100.1		25.86	6,907	.63	
35	250.3	3,574	2,916	1,762	243.6	67.94	7.1	324.4		7.36	8,992	.35	
36	0	3,985	8,996	2,582	323.2	49.21	5.11	85.94		10.71	9,015	.17	
37	0	3,681	9,049	2,637	609.7	67.8	2.98	36.96		16.49	3,976	.59	
38	60.21	3,138	9,122	2,364	609.8	72.22	2.31	22.81		13.81	3,003	.68	
39	382.2	1,282	9,139	4,916	95	22.5	3.58	166.2		2.35	4,973	.12	
40	404.4	3,665	9,061	5,874	268.7	65.4	5.43	207.2		8.35	8,691	.52	
41	377.2	3,545	8,852	11,010	223.7	76.03	12.14	507		21.71	8,965	.48	
42	147.7	4,549	2,491	2,250	272.2	94.23	2.84	4.8		22	3,876	.63	
43	0	4,227	3,650	2,208	294.8	88.54	6.82	33.4		23	5,732	.59	
44	327.8	4,807	3,367	3,972	150.4	69.85	13.52	532.7		15.46	8,967	.38	
45	444.6	3,163	8,714	9,910	221.7	55.38	14.47	854.4		14.88	8,934	.43	
46	372.1	6,666	4,961	4,599	321.7	77.64	13.06	556.8		18.2	8,969	.47	
47	212.1	4,813	3,449	4,261	197.8	74.98	11.8	622.2		11.91	8,954	.32	
48	417.6	4,015	8,855	9,868	298.7	57.81	6.39	458.8		18.25	8,990	.39	
49	261.7	3,735	9,042	4,872	207.7	77.13	10.16	535.2		12.83	8,975	.33	
50	168.7	5,203	8,989	4,995	267.4	70.74	9.01	412		16.04	8,983	.32	
51	189.2	3,871	8,934	9,024	288	59.44	4.34	182.6		20.17	7,587	.4	
52	235.5	5,628	5,604	4,524	291.5	73.59	11.34	527.7		15.89	8,986	.37	
53	512.7	5,301	3,551	3,096	281	74.97	17.82	614.9		17.61	8,968	.58	
54	254.2	5,768	2,716	3,305	274.5	76.62	13.1	533.2		14.13	8,969	.36	
55	199.7	6,652	3,051	4,054	278.3	76.11	12.56	575.6		13.42	8,972	.29	
56	198.7	4,920	3,020	3,621	283.1	69.11	13.67	668.7		10.99	8,963	.31	
57	621	6,603	9,032	3,327	304.5	79.62	14.68	383.4		20.82	8,989	.43	
58	621.6	6,115	9,046	3,425	274	74.93	8.93	340.8	0	19.75	9,010	.42	0

Table 6
Diethylenetriamin pentacetic acid (DTPA)
soil analysis
(Unit--parts per million)

	Nickel (Ni)	Cadmium (Cd)	Lead (Pb)		Nickel (Ni)	Cadmium (Cd)	Lead (Pb)
1	2.2	0.07	0.84	30	0.6	0.01	0.21
2	1.6	.03	.82	31	4	.07	2.59
3	3	.14	1.24	32	1.3	.03	1.42
4	1	.01	.85	33	4.7	.11	4.13
5	1.4	.02	.90	34	3.8	.08	3.23
6	.7	.01	.14	35	1.5	.06	.68
7	3.1	.60	2.60	36	1.2	.01	.69
8	.7	0	0	37	2.9	.14	1.01
9	2.2	0.10	1.12	38	2.5	.16	.83
10	2.9	.06	3.10	39	.9	.03	.35
11	2.6	.14	1.34	40	2.4	.08	1.62
12	2.4	.04	1.98	41	2.7	.08	1.74
13	2.4	.02	.59	42	3.9	.08	2.26
14	1	.01	.32	43	2.9	.05	3.25
15	7	.03	2.66	44	1.6	.06	.65
16	1.2	.04	.98	45	1.1	.01	.39
17	2.2	.03	.74	46	1.6	.04	.55
18	1.3	.14	.55	47	1.5	.05	.61
19	1.2	.04	.32	48	1.1	0	.71
20	1.3	.03	.22	49	2	0.08	.65
21	1.9	.05	2.30	50	1.9	.04	.63
22	1.7	.03	2.20	51	2.1	.02	.84
23	.9	.01	.52	52	2.6	.06	.54
24	.7	.01	0	53	1.5	.10	.66
25	3.7	.07	2.79	54	2	.11	.50
26	1.5	.07	.64	55	2	.04	.56
27	1.3	.04	.50	56	1.9	.03	.46
28	.9	.02	.27	57	1.5	.10	.68
29	.8	.01	.17	58	1.4	.08	.62

Table 7
300 series preplant available soil analysis
(Unit--parts per million)

Analysis	Mean	Ranges	Standard deviation	Coefficient of variation
pH	7.7	6 - 8.8	0.59	0.08
Cation exchange capacity (CEC)	16.1	3.5- 34	6.23	.39
Phosphorus (P)	1.81	0 - 25	4.38	2.42
Potassium (K)	85.22	11 -510	83.65	.98
Zinc (Zn)	2.95	0.1- 17	3.89	1.32
Copper (Cu)	.22	.1- 1.6	.27	1.23
Iron (Fe)	-	-	-	-
Manganese (Mn)	20.67	0.4-117	20.75	1.00
DTPA[1/] nickel (Ni)	2.00	.6- 7	1.14	.57
DTPA[1/] cadmium (Cd)	.06	0 - 0.6	.08	1.33
DTPA[1/] lead (Pb)	1.10	0 - 4.13	.95	.86

1/ Diethylenetriamin pentacetic acid (DTPA).

Table 8
300 series preplant total soil analysis
(Unit--parts per million)

Analysis	Mean	Ranges	Standard deviation	Coefficient of variation
Phosphorus (P)	306.4	0 - 621.6	138.20	0.45
Potassium (K)	3,862.0	380.4 - 6,666	1,571.60	.41
Calcium (Ca)	6,875.0	2,152 - 9,177	2,777.23	.40
Magnesium (Mg)	5,550.0	1,601 -11,080	2,948.40	.53
Zinc (Zn)	68.05	7.13- 119.5	24.38	.36
Boron (B)	7.74	1.08- 17.82	3.86	.50
Manganese (Mn)	356.79	4.8 - 854.4	189.56	.53
Molybdenum (Mo)	-	-	-	-
Copper (Cu)	15.60	1.65- 54.34	8.58	.55
Cadmium (Cd)	.40	.02- .71	.17	.43
Lead (Pb)	-	-	-	-
Arsenic (As)	24.22	0 - 51.22	13.47	.56

Table 9
300 series postharvest soil analysis available

	Soil pH	Cation exchange capacity (CEC)	Unit--parts per million Phosphorus (P)	Potassium (K)	Zinc (Zn)	Copper (Cu)	Manganese (Mn)
1	7.7	12.1	5	139	0.6	0.1	12
2	7.9	29.6	0	46	.8	.1	19
3	8	36.1	0	85	3.2	.1	60
4	8.6	34.6	0	58	1.6	.2	25
5	8.1	35	0	62	2.3	.1	175
6	8.6	15	9	100	1.9		13
7	8.1	29.1	1	130	7.2		72
8	8.7	17.5	8	131	8.9		45
9	8	12.5	8	200	.5	.1	7.1
10	8.5	32.1	1	59	.4	.2	9.1
11	8.3	24.1	5	87	2.3	.1	99
12	8.6	24.7	0	134	8.7	.1	48
13	8.5	37.8	9	63	2.3	.2	43
14	8.7	20.5	0	52	3.2	.1	101
15	8.5	24.5	0	160	4.3		129
16	8.6	17.9	0	126	5.5		77
17	8.3	23.4	0	183	13		58
18	8.3	10	11	168	1.6		9.8
19	5.6	9.8	7	71	1.7		6
20	6.5	15	3	19	.7	.1	5.3
21	6.9	23.2	6	175	12	.7	15
22	7.4	17.2	2	216	5.6	.3	24
23	7.3	19.2	9	101	7	.1	22
24	7.7	3.4	23	152	17	.2	11
25	7.6	9.9	3	319	18	.4	13
26	7.2	13.2	10	192	1.3	.1	5.4
27	7.6	20.6	3	54	.4	.1	10
28	7.8	21.2	4	31	.8	.1	19
29	8.6	25.5	0	44	.7	.1	7.7
30	8.4	11.7	14	128	25	2.6	25
31	7.4	27	0	228	7.4	.2	81
32	8.6	21	3	218	14	3.2	64
33	5.3	21.4	5	222	33	3.3	2.9
34	7.4	16.5	5	240	9.4	.3	11
35	7	15.5	6	165	1	.1	5.7
36	7.4	26.8	3	62	1.3	.2	4.6
37	6.6	30.8	10	51	1.2	.1	1
38	7.5	30.8	24	93	2.5	.1	0.4
39	8.6	6	14	182	8.2	.1	34
40	7.1	11.3	4	195	11	.1	28
41	8.2	21.8	0	146	11	2.1	101
42	6.6	13.4	6	171	14	.4	10
43	6.3	10.7	4	200	8.1	.1	5.3
44	7	15.1	12	188	1.1		7.8
45	8.3	30.2	0	45	4		63
46	8.3	27.3	1	61	2		27
47	8	18.2	3	62	0.7		6.8
48	8	29.1	0	38	.8		40
49	7.8	18.3	11	159	.7	.1	6.2
50	8.2	27.3	2	51	11	.3	5.6
51	8.4	30.3	0	40	2.1	.1	12
52	8.3	20.7	6	66	.7	.2	11
53	8.1	12	12	298	1.5	.1	9.8
54	7.9	11.5	3	231	.3		7.3
55	6.6	12	4	173	.9		13
56	8	14.1	2	80	.4		6.2
57	8	27.7	43	815	.6		3.8
58	8	28.3	24	483	.8	.1	6

Table 10
300 series postharvest DTPA1/
(Unit--parts per million)

300 series (post-harvest)	DTPA1/ nickel (Ni)	Cadmium (Cd)	Lead (Pb)	300 series (post-harvest)	DTPA1/ nickel (Ni)	Cadmium (Cd)	Lead (Pb)
301	2.2	0.07	0.78	330	0.7	0.01	0.36
302	1.9	.02	.72	331	-	-	-
303	2.3	.10	.87	332	1.4	0.01	0.74
304	1	0	.76	333	5.9	.12	2.11
305	1.5	0.02	.86	334	1.7	.05	1.28
306	.8	.02	.24	335	-	-	-
307	2	.05	1	336	-	-	-
308	0.9	.01	0.35	337	-	-	-
309	2.2	.10	1.03	338	-	-	-
310	2.2	.03	.88	339	0.8	0.03	0.19
311	2.2	.10	.90	340	-	-	-
312	1.1	.04	.98	341			
313	2.1	0	0	342			
314	1.4	0.06	1	343			
315	3.6	0	0.71	344	-	-	-
316	1.3	0	.12	345	1.3	0	0.36
317	2.4	0.01	.33	346	1	0.03	.45
318	1.7	.11	.62	347	1	.04	.42
319	1.3	.09	.49	348	-	-	-
320	.8	.04	.30	349	1.5	-	-
321	2.2	.04	1.31	350	1.7	0.04	0.55
322	1.8	.02	.72	351	1.3	.02	.67
323	.7	.01	.21	352	2.0	.05	.38
324	.5	0	.15	353	1.3	.09	.88
325	2.4	0.06	1.14	354	1.5	.05	.46
326	1.1	.06	.55	355	-	-	-
327	1.1	.03	.33	356	1.8	0.01	0.45
328	.9	.02	.43	357	1.5	-	-
329	.8	.07	.26	358	1.5	0.07	0.64

1/ Diethylenetriamin pentacetic acid (DTPA).

Table 11
300 series postharvest soil analysis total
(Unit--parts per million)

	Phosphorus (P)	Potassium (K)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Zinc (Zn)	Boron (B)	Manganese (Mn)	Molybdenum (Mo)	Copper (Cu)	Iron (Fe)	Cadmium (Cd)	Lead (Pb)
1	316.2	2,079	27,810	20,070	393.4	37.81	8.63	264.5	0	11.21	9,420	0.31	0
2	337.9	2,533	27,780	20,660	547	42.05	9.3	268.1		11.23	8,915	.28	
3	273.2	4,015	27,810	17,560	725.6	60.05	9.73	329.7		21.03	10,000	.25	
4	417.2	3,197	8,866	6,131	426.6	55.84	12.29	343.7		9.10	9,851	.38	
5	328.2	2,592	27,730	13,350	385.8	43.18	13.19	228		9.53	10,000	.21	
6	352.9	3,305	27,680	15,570	487.9	50.97	11.39	249.4		11.14	8,350	.28	
7	635.2	1,842	23,120	11,510	269.2	37.65	8.93	218.1		3.71	8,926	.25	
8	349.6	1,391	23,210	8,009	240.6	43.08	9.11	270.3		4.53	10,000	.20	
9	465.1	3,307	2,679	2,283	325.9	68.4	15.13	457.4		12.06	10,000	.46	
10	330	3,319	17,820	4,733	487.5	68.35	13.02	332.6		10.66	10,000	.66	
11	394.8	3,261	3,857	2,843	350.1	89.25	10.72	503.2		7.86	10,000	.64	
12	330.5	3,919	25,460	13,250	555.8	58.72	12.02	258.3		12.70	8,370	.21	
13	265.6	2,804	12,670	4,044	305.4	89.67	8.47	252		16.01	10,000	.71	
14	440.6	3,655	23,040	9,488	389.7	93.18	15.9	508.2		14.22		.61	
15	426	1,809	23,150	9,828	212.8	47.03	14.54	347.1		9.63		.3	
16	269.2	3,853	18,530	6,564	418.3	99.08	12.95	275.8		13.99		.70	
17	420.8	3,386	23,170	8,917	788.8	84.12	10.19	364.2		13.73		3.83	
18	624.6	2,844	2,712	1,611	290.6	80.88	18.63	487.6		10.41		.73	
19	469.9	2,213	1,831	1,331	290.6	78.84	10.04	327.5		8.45		.43	
20	435.1	2,105	3,099	1,506	265.1	351.9	11	254.1		7.70	10,000	.34	
21	380	3,229	8,961	4,862	487.7	1,056	4.48	114.7		20.83	6,427	.54	
22	419.2	2,675	5,987	4,302	441.5	325.3	7.92	351.8		16.83	10,000	.47	
23	318.3	764	17,070	7,452	185.9	881.7	3.96	186		4.31	5,866	.26	
24	303.6	641	10,610	6,008	156.3	84.32	4.55	97.4		1.91	5,187	.19	
25	621.4	1,846	2,550	1,037	1,253	114.9	2.73	69.4		15.15	4,911	.63	
26	418.5	3,918	3,176	2,524	426.4	88.39	14.68	438.7		14.86	10,000	.46	
27	219.1	3,159	7,450	2,832	370	82.56	14.76	390.5		12.63	10,000	.44	
28	342.3	2,120	26,890	4,701	296.1	70.89	9.99	259.5		10.67	9,428	.27	
29	289.7	1,712	27,790	7,135	302.1	55.5	7.47	217.7		7.16	7,936	.34	
30	281	1,045	6,862	2,911	149.3	66.22	4.35	97.9		2.11	4,391	.25	
31	467.4	1,179	14,700	7,222	254.6	91	4.7	415.3		19.67	8,675	.42	
32	510.9	2,457	27,900	10,490	319.3	53.19	8.72	309.8		9.17	10,000	.33	
33	115.9	5,234	2,048	2,050	545.1	153.4	4.33	22.2		22.01	4,543	.85	
34	158.5	4,038	3,677	2,476	471.7	114.1	5.56	95.5		24	6,773	.67	
35	309.7	3,959	2,858	2,428	457.3	94.53	14.68	435.9		11.54	10,000	.54	
36	74	1,567	9,010	1,665	335.6	44.59	4.48	75.1		8.84	8,104	.15	
37	75.4	754	9,337	1,599	457.8	57.88	1.46	26.33		11.17	2,855	.38	
38	123.3	2,388	8,179	1,838	566.9	98.42	3.13	23.2		16.87	2,933	.74	
39	443.2	1,275	9,906	4,664	188.3	38.67	5.56	142.2		3.47	5,047	.09	
40	417.9	3,413	8,373	5,354	418	77.03	8.6	178.1		9.62	8,692	.70	
41	415.1	3,031	27,810	11,230	375.5	92.64	10.71	423.7		16.58	10,000	.40	
42	214	3,717	2,254	1,397	421.8	110.1	5.32	35.7		17.18	3,281	.73	
43	137.9	749	2,154	626	217.3	72.99	1.92	12.09		12.95	2,898	.47	
44	389.9	3,516	2,789	2,696	355.2	74.48	13.21	428.5		12.08	10,000	.39	
45	393	3,598	2,786	2,954	294.6	153.1	9.7	858		0		.17	
46	281.3	2,566	21,580	6,983	222	762	9.63	208.2		7.15		.32	
47	494.6	4,405	3,705	4,518	463	75.55	15.73	550.7		11.88		.40	
48	478.6	973	14,560	6,699	225.5	50.32	6.52	453.9		12.77		.34	
49	455.5	2,139	22,570	9,080	204.2	168.9	14.18	477.8		12.94		9.25	
50	345.7	1,913	24,230	7,465	449.1	66.99	10.23	453.4		7.97		.32	
51	246.9	2,262	27,620	15,190	359.4	42.13	10.48	284.3	0	11.99		.32	
52	331.2	1,050	27,800	53,260	109.4	2,225	9.98	1,870	17	47.56		.58	
53	248.9	863	27,790	5,761	144.9	74.61	13.13	2,372	22	75.42		.56	
54	661.7	3,099	3,528	3,037	481.7	90.04	17.23	716.5	0	9.93		.47	
55	318.1	1,867	2,659	1,866	194	64.88	10.46	530.8		8.4		.02	
56	643	2,773	14,930	5,252	502.9	71.11	10.09	445.7		8.66	10,000	.43	
57	306.1	1,895	27,850	19,100	278.1	38.22	7.49	221		9.19	8,494	.14	
58	376	2,182	27,720	12,890	390.7	42.01	10.4	284.6	0	11.16	10,000	.32	0

Table 12
300 series postharvest available soil analysis
(Unit--parts per million)

Analysis	Mean	Range	Standard deviation	Coefficient of variation
pH	7.8	5.3 - 8.7	0.77	0.10
Cation exchange capacity (CEC)	20.7	3.4 - 37.8	8.16	.39
Phosphorus (P)	6	0 - 43	7.62	1.27
Potassium (K)	146	19 -815	122.50	.84
Zinc (Zn)	5.31	0.3 - 33	6.52	1.23
Copper (Cu)	.33	.1 - 3.3	.69	2.09
Iron (Fe)	-	-	-	-
Manganese (Mn)	30	0.4 -175	35.70	1.19
DTPA[1/] nickel (Ni)	1.62	.5 - 5.9	.91	.56
DTPA[1/] cadmium (Cd)	.04	0 - .12	.03	.75
DTPA[1/] lead (Pb)	.65	0.12- 2.11	.38	.58

1/ Diethylenetriamin pentacetic acid (DTPA).

Table 13
300 series postharvest total soil analysis
(Unit--parts per million)

Analysis	Mean	Range	Standard deviation	Coefficient of variation
Phosphorus (P)	360.5	74 - 661.7	133.07	0.37
Potassium (K)	2,541	641 - 5,234	1,069.85	.42
Calcium (Ca)	14,650	1,831 -27,900	10,096.73	.69
Magnesium (Mg)	7,462	626 -53,260	7,925.63	1.06
Zinc (Zn)	163.86	37.65- 2,225	333.06	2.03
Boron (B)	9.62	1.46- 18.63	4.02	.42
Manganese (Mn)	364.03	12.09- 2,372	376.34	1.03
Molybdenum (Mo)	.67	0 - 22	3.59	5.36
Copper (Cu)	13.03	0 - 75.42	10.69	.82
Cadmium (Cd)	.62	0.02- 9.25	1.24	2
Lead (Pb)	-	-	-	-
Arsenic (As)	24.22	0 - 51.22	13.47	0.56

Table 14
300 series plant tissue analysis

	Unit--percent				Unit--parts per million									
	Phosphorus (P)	Potassium (K)	Calcium (Ca)	Magnesium (Mg)	Arsenic (As)	Zinc (Zn)	Boron (B)	Manganese (Mn)	Molybdenum (Mo)	Copper (Cu)	Iron (Fe)	Cadmium (Cd)	Lead (Pb)	Dry weight
1	0.56	3.12	0.7	0.39	0.51	56.25	15.48	56.85	0.2	10.6	409.05	0.72	0	3.32
2	.47	3.3	.71	.52	2.65	52.65	13.43	53.35	.9	13.14	230.15	.41	0	2.81
3	.28	1.87	.56	.73	0	44.85	8.51	70.55	.4	7.3	166.6	.43		3.58
4	.49	2.7	.41	.76	0.11	45.98	20.8	52.75	3.68	13.78	190.35	.67		2.94
5	.27	1.77	.54	1.13	0	65.3	16.71	73.5	1.79	7.58	124.3	.16		4.25
6	.45	2.13	.5	.34	6.94	78.45	15.27	104.25	2.09	12.49	272.5	.33		3.17
7	.31	2.37	.89	.43	6.94	99.2	17.79	128.9	3.38	6.96	319.95	.11		4.66
8	.38	2.34	.7	.57	6.24	87.25	15.38	88.9	1.2	9.76	1,442	.45		1.15
9	.66	4.06	.59	.35	0	47.73	10.96	38.76	.1	9.91	196.85	.85		3.05
10	.41	3.03	.56	.56	1.88	44.2	14.28	47.78	3.74	12.06	328.9	.47		2.44
11	.49	2.57	.56	.66	5.44	88.6	9.56	137.7	1	10.14	365	.56		3.91
12	.53	3.6	.38	.61	2.57	77.85	10.52	84.15	7.2	8.92	208.7	.48		3.38
13	.36	1.16	.57	1.48	0	80.35	18.7	82.65	7.29	10.5	185.8	.39		2.4
14	.43	2.25	.45	.51	0.64	66.95	14.54	55.7	5.29	10.53	193.3	.16		3.39
15	.32	3.2	.58	.61	2.57	54.3	11.38	113.35	6.02	10.72	196.9	.31		2.67
16	.46	2.68	.58	.41	6.52	64.5	12.93	53.15	2.37	6.42	387.85	.12		2.89
17	.42	2.89	.74	.38	3	84.8	17.39	126.1	6.84	8.47	245.4	.66		3.54
18	.68	3.81	.63	.22	4.03	69.2	10.49	41.67	1.19	8.18	273.3	.66		3.52
19	.55	2.12	.74	.24	5.62	64.45	18.37	33.17	3.09	6.24	313.9	0		3.66
20	.56	2.53	.85	.34	3.71	44.11	13.94	54.25	4.58	12.74	191.55			3.59
21	.42	3	.73	.54	5.16	63.05	18.52	84.85	14.76	7.43	161.3			3.9
22	.3	3.41	.54	.41	2.38	44.63	13.95	86.9	4.58	7.18	377.8			2.11
23	.45	2.95	.47	.36	11.65	68.8	25.04	57.85	2.98	3.91	285.7			1.82
24	.36	2.3	.39	.39	5.23	63.75	26.13	64.45	1.15	6.37	213.3			1.42
25	.61	1.52	.2	.12	10.39	73.85	14.17	81.8	2.29	7.48	233.6			3.21
26	.51	3.78	.78	.28	9.93	89.9	17.81	43.33	.69	7.35	310.05			2.78
27	.39	2.42	.79	.27	2.38	43.18	14.38	52.5	.57	8.51	217.35			3.04
28	.52	2.21	.77	.32	4.7	38.8	21.33	70.45	1.95	6.03	105.45			3.71
29	.39	1.77	.41	.5	4.3	79.05	26.07	77.8	4.35	6.12	200.9			2.99
30	.44	1.7	.58	.28	13.56	157.85	29.86	180.45	3.32	5.44	455.15			2.93
31	.31	2.89	.72	.46	45.3	79.6	12.79	166.35	2.63	7.88	1,416.5			4.14
32	.39	2.67	.51	.43	6.35	103.45	28.97	60.7	5.26	9.36	348.15			1.97
33	.26	2.53	.32	.45	.66	82.35	55.55	36.29	1.83	5.41	115.4			3.09
34	.4	3.22	.51	.45	1.33	50.15	20.31	85.9	3.89	6.64	111.2			3.72
35	.5	3.24	.56	.27	4.37	52.95	15.38	36.59	1.72	5.58	149.05			3.64
36	.4	2.38	.7	.31	18.25	81.25	18.55	35.26	.92	8.93	888.5			1.5
37	.37	1.97	.91	.49	10.45	240.2	18.19	26.41	1.95	10.92	246.65			3.77
38	.55	2.49	.9	.46	3.64	506.5	9.23	23.12	1.49	6.67	157.9	0		3.68
39	.44	2.86	.41	.29	6.44	63.7	28.67	55.55	3.05	9.37	242.9	0.19		1.31
40	.35	1.97	.72	.41	14.53	93.45	24.3	105.95	1.13	11.3	619	.24		1.71
41	.41	2.62	.73	.59	7.98	93.2	25.09	128.4	14.32	12.85	721	.36		3.97
42	.44	2.97	.76	.52	10.64	80.5	57.75	104.65	2.82	8.67	175.95	.81		3.8
43	.41	2.76	1.79	.59	9.84	67.6	45.39	74.65	3.16	8.59	319.45	0		3.28
44	.48	3.24	.7	.25	7.18	57.85	23.77	64.85	.79	8.7	399.85	0.75		4.07
45	.37	1.76	1.23	.57	11.38	63.55	38.38	152.75	2.03	12.24	1,322	0		3.65
46	.39	2.17	1.03	.4	9.65	62.05	19.26	75.2	2.59	10.88	509.5	0		1.78
47	.36	3.6	.71	.31	3.78	46.21	20	71.05	1.36	9.28	231.85	0.44		3.64
48	.45	2.58	.73	.56	10.07	64.05	31.11	146.3	6.53	14.02	397.5	0		3.51
49	.56	3.36	.95	.27	12.18	64.1	14.88	63.4	1.92	12	392.1	0.54		4.35
50	.45	2.59	1.25	.42	7.18	67.4	25.07	59.65	2.26	11.98	538	.61		2.33
51	.45	2.58	.76	.58	11.56	92.1	30.72	80.2	2.26	12.46	359.05	.54		4.32
52	.33	2.24	1.01	.28	27.25	47.27	14.09	101.75	.79	13.16	1,748	.75		5.29
53	.52	2.88	.79	.24	7.05	63.4	25.16	64.8	1.47	8.88	348.55	.24		4.16
54	.57	3.46	.73	.27	6.13	52.35	18.38	74.6	1.69	9.63	545	.84		4.3
55	.33	2.44	.92	.35	14.41	83.4	25.69	89.5	1.36	8.63	819	.62		3.5
56	.6	4.36	1.17	.25	9.09	211.45	26.96	39.61	2.93	10.17	341.75	.16		3.7
57	.45	3.74	.78	.26	21.31	1,209.5	24.33	105.95	0	11.97	1,535	.63		3.1
58	.58	4.02	1	.23	9.71	3,751	26.56	48.52	2.93	13.47	319.65	.04	0	4.71

Table 15
300 series plant tissues analysis
(Unit--parts per million)

Analysis	Mean	Range	Standard deviation	Coefficient of variation
Dry weight (grams)	3.24	1.15- 5.29	0.90	0.28
Phosphorus (P)	.44	.26- .68	.10	.23
Potassium (K)	2.73	1.16- 4.36	.68	.25
Calcium (Ca)	.71	.2 - 1.79	.26	.37
Magnesium (Mg)	.44	.12- 1.48	.22	.50
Arsenic (As)	7.53	0 - 45.3	7.35	.98
Cadmium (Cd)	.27	0 - .85	.29	1.07
Lead (Pb)	-	-	-	-
Zinc (Zn)	165.00	38.8 -3,751	501.49	3.04
Boron (B)	21.00	8.51- 57.75	9.90	.48
Manganese (Mn)	77.17	23.12- 180.45	35.14	.46
Iron (Fe)	415.89	105.45-1,748	370.18	.89
Copper (Cu)	9.34	3.91- 14.02	2.48	.27
Molybdenum (Mo)	3.00	0 - 14.76	2.82	.94

Table 16
300 series correlation of dry weight
of plants versus preplant and postharvest
available soil analysis

Dry weight versus	Correlation coefficient Preplant	Postharvest
pH	-0.329	-0.123
Cation exchange capacity (CEC)	.225	.152
Phosphorus (P)	.191	-.046
Potassium (K)	.248	.063
Zinc (Zn)	.021	.248
Copper (Cu)	-.027	-.105
Iron (Fe)	-	-
Manganese (Mn)	0.157	0.060
DTPA1/ nickel (Ni)	.219	.219
DTPA1/ cadmium (Cd)	.366	.374
DTPA1/ lead (Pb)	.091	.092

1/ Diethylenetriamin pentacetic acid (DTPA).

Table 17
300 series correlation of dry weight
of plants versus preplant and postharvest
total soil analysis

Dry weight versus	Correlation coefficient	
	Preplant	Postharvest
Phosphorus (P)	-0.113	0.153
Potassium (K)	.282	.123
Calcium (Ca)	-.175	.070
Magnesium (Mg)	-.099	.276
Zinc (Zn)	.334	.171
Boron (B)	.270	.225
Manganese (Mn)	.240	.376
Molybdenum (Mo)	-	.294
Copper (Cu)	0.296	.379
Cadmium (Cd)	.309	.195
Lead (Pb)	-	-
Arsenic (As)	-	0.072

Table 18
300 series correlation
between dry weight of plants
and plant tissue analysis

Dry weight versus	Correlation coefficient
Phosphorus (P)	0.177
Potassium (K)	.146
Calcium (Ca)	.270
Magnesium (Mg)	-.640
Arsenic (As)	.156
Cadmium (Cd)	.209
Lead (Pb)	-
Zinc (Zn)	0.209
Boron (B)	-.035
Manganese (Mn)	.166
Copper (Cu)	.124
Molybdenum (Mo)	.058

Summary and Conclusion

In general the analyses of both soils and plants did not indicate any unusual problems. Boron values were high in some soils which could result in phytotoxicity in sensitive plants. Arsenic levels were also high for several samples.

ACKNOWLEDGEMENTS

E&A Environmental Consultants, Inc. acknowledges cooperation of the following individuals during the course of this study.

Gregory Brockman	Bureau of Reclamation
Robert Montgomery	Bureau of Reclamation
Dr. Gerald Schuman	U.S. Department of Agriculture
Scott Fisher	Bureau of Land Management
Dr. William Feder	University of Massachusetts
Dr. G. Smith	University of New Mexico
Dr. Brian Sindelaer	University of Wyoming

Without the assistance of these project officers and consultants, it would have been virtually impossible to complete this study in the limited time frame available.

APPENDIX E

WEATHERING TESTS

Weathering Tests Conducted on
Core Samples from
Collom Gulch, Colo.

United States Department of the Interior
Bureau of Reclamation
Engineering and Research Center
Materials Science Section
Denver, Colo.

APPENDIX E

WEATHERING TESTS

Results of Weathering Tests Conducted on Core Samples from Collom Gulch, Colo.1/

Laboratory weathering and outdoor exposure tests were conducted on overburden core samples from the Collom Gulch, Colo., study area. The purpose of these tests was to determine which materials would break down sufficiently to allow for their possible use as planting media in revegetation of strip-mined areas.

Test Procedures

Specimens for the laboratory weathering and outdoor exposure tests were cut from core samples submitted by Mr. Greg Brockman, D-737, on September 22, 1981.

The purpose of including outdoor exposure tests was to determine if any correlation could be drawn between this type of weathering and the laboratory weathering conditions.

A laboratory weathering cycle consisted of the following conditions.

1. 8 hours at 23.9° C (75° F), 100 percent relative humidity (wetting/thawing)

2. 16 hours (64 hours on weekends) at 37.8° C (100° F), 10 percent relative humidity (drying)

3. 8 hours at 23.9° C (75° F), 100 percent relative humidity (wetting)

4. 16 hours (64 hours on weekends) at -17° C (0° F) (Freezing)

In this study, core specimens about 50 mm2/ (2 inches) in diameter by 50 mm (2 inches) in length were used. For testing and handling, the core specimens were placed on a No. 10-mesh screen in 400-ml2/ plastic beakers.

1/ Applied Sciences Referral Memorandum No. 82-1-12, Bureau of Reclamation.

2/ Explanations: mm = millimeter; ml = milliliter.

Laboratory weathering tests were started on October 19, 1981, and 20 laboratory weathering cycles were completed on December 16, 1981. For natural weathering, the core specimens were placed in the outdoor exposure test area at the E&R Center[1/] on October 19, 1981. These specimens were evaluated after 1 year of weathering. During this period of time, the specimens were subjected to about 330 mm (13 inches) of precipitation.

Test Results

Test results are summarized in Table 1, and shown visually in Figures 1 through 14.

At the completion of the laboratory weathering tests, a percent breakdown value (%BD) was determined for the specimens. This value listed under the remarks column in the table was derived as follows.

$$\%BD = \frac{(TW - IW)}{TW}(100)$$

where TW = total specimen weight
IW = weight of original specimen remaining intact after testing

In addition, the percent by weight passing a No. 10-mesh screen was determined for the specimens.

Of the 14 samples tested, 6 sample (4 sandstone and 2 siltstone) materials exhibited no breakdown at all. Of the remaining 8 samples, 6 weathered sufficiently to attain the soil texture necessary as a planting medium (minimum of 30 percent by weight passing a No. 10 screen). These included shale samples 3, 6, and 13; and siltstone samples 2, 8, and 11.

With regard to the correlation between laboratory and outdoor weathering, the same type of breakdown of the specimens was observed in both cases. Based upon the percent breakdown value (%BD), however, the outdoor weathering was more severe.

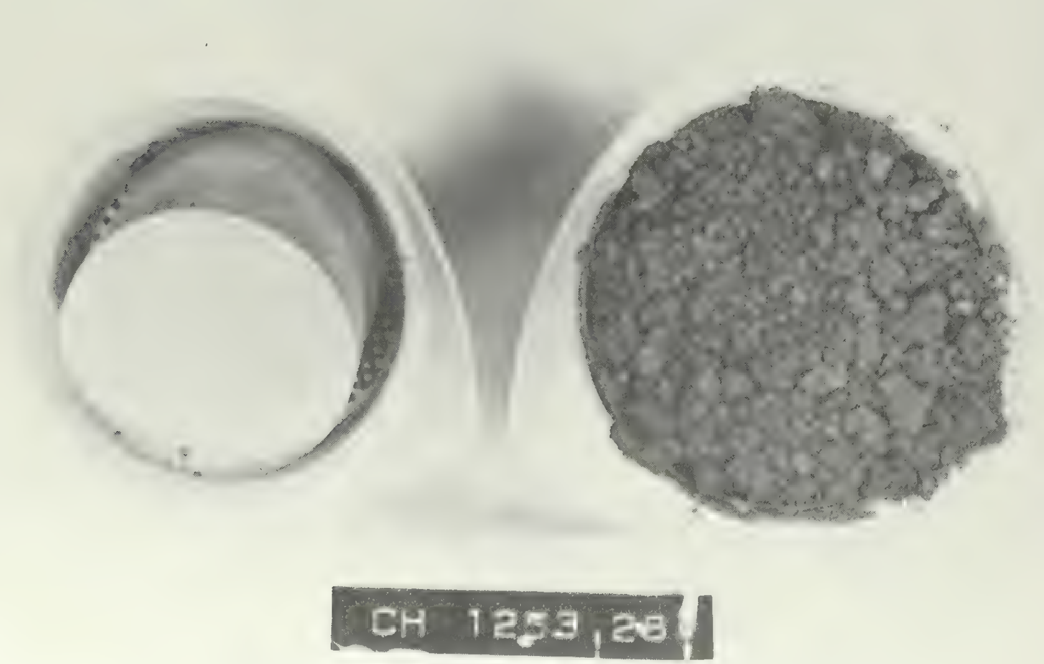
1/ Engineering and Research Center.

Table 1
Results of 1-year outdoor weathering for core samples from Collom Gulch, Colo.

Laboratory sample number	Sample I.D. Sample	Depth (feet)	Remarks: Laboratory weathering	Remarks: Outdoor	Reference
1	Sandstone DH-1	96.0- 96.7	No change at 20 cycles. %BD = 0.	No change at 1 year. %BD = 0.	See Figures 1 and 2
2	Siltstone DH-1	136.0-136.4	Breakdown at 5 cycles. %BD = 100; % passing No. 10 screen = 63.	Breakdown at 1 year; whitish residue noted. %BD = 100; % passing No. 10 screen = 25.	See Figures 1 and 8
3	Shale DH-2	40.5- 41.0	Slight slaking at 5 cycles; continued slaking at 20 cycles. %BD = 46; % passing No. 10 screen = 8.	Breakdown and some swelling at 1 year. %BD = 100; % passing No. 10 screen = 45.	See Figures 2 and 9
4	Siltstone DH-2	159.0-159.8	No change at 20 cycles. %BD = 0.	No change at 1 year. %BD = 0.	See Figures 2 and 9
5	Sandstone DH-2	292.0-292.5	No change at 20 cycles. %BD = 0.	No change at 1 year.	See Figures 3 and 10
6	Shale DH-3	49.0- 49.3	Slight slaking at 5 cycles; continued slaking at 20 cycles. %BD = 100; % passing No. 10 screen = 6.	Breakdown at 1 year; whitish residue noted. %BD = 100; % passing No. 10 screen = 54.	See Figures 3 and 10
7	Sandstone DH-3	105.5-106.0	No change at 20 cycles. %BD = 0.	No change at 1 year. %BD = 0.	See Figures 4 and 11
8	Siltstone DH-3	239.0-239.5	Slaking at 5 cycles; continued slaking at 20 cycles. %BD = 100; % passing No. 10 screen = 57.	Breakdown at 1 year; whitish residue noted. %BD = 100; % passing No. 10 screen = 26.	See Figures 4 and 11
9	Sandstone DH-4	35.0- 35.5	No change at 20 cycles. %BD = 0.	No change at 1 year. %BD = 0.	See Figures 5 and 12
10	Shale DH-4	77.0- 77.5	Slaking and swelling at 5 cycles; continued slaking at 20 cycles. %BD = 28; % passing No. 10 screen = 8.	Breakdown at 1 year. %BD = 100; % passing No. 10 screen = 27.	See Figures 5 and 12
11	Siltstone DH-4	102.0-102.7	Slaking at 5 cycles; continued slaking at 20 cycles. %BD = 0; % passing No. 10 screen = 13.	Breakdown at 1 year; whitish residue noted. %BD = 100; % passing No. 10 screen = 43.	See Figures 6 and 13
12	Sandstone DH-5	84.6- 85.4	Cracking and swelling at 5 cycles; continued swelling and cracking at 20 cycles. %BD = 40; % passing No. 10 screen = 4.	Breakdown at 1 year. %BD = 110; % passing No. 10 screen = 24.	See Figures 6 and 13
13	Shale DH-5	200.0-200.4	Swelling and breakdown at 5 cycles; continued swelling at 20 cycles. %BD = 100; % passing No. 10 screen = 78.	Breakdown at 1 year; whitish residue noted. %BD = 100; % passing No. 10 screen = 79.	See Figures 7 and 14
14	Siltstone DH-5	254.2-255.0	No change at 20 cycles. %BD = 0.	No change at 1 year. %BD = 0.	See Figures 7 and 14

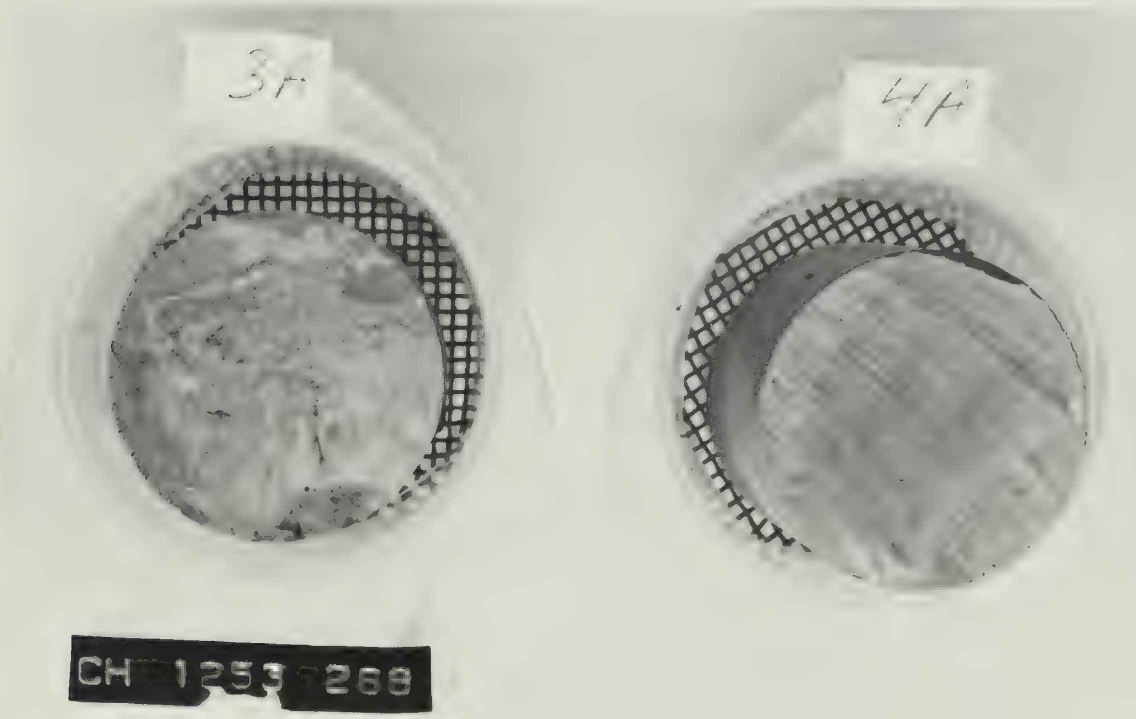
Figure 1
Results of weathering tests for sandstone sample 1A and siltstone sample 2A subjected to 20 laboratory weathering cycles.

a. Original condition of test specimens.

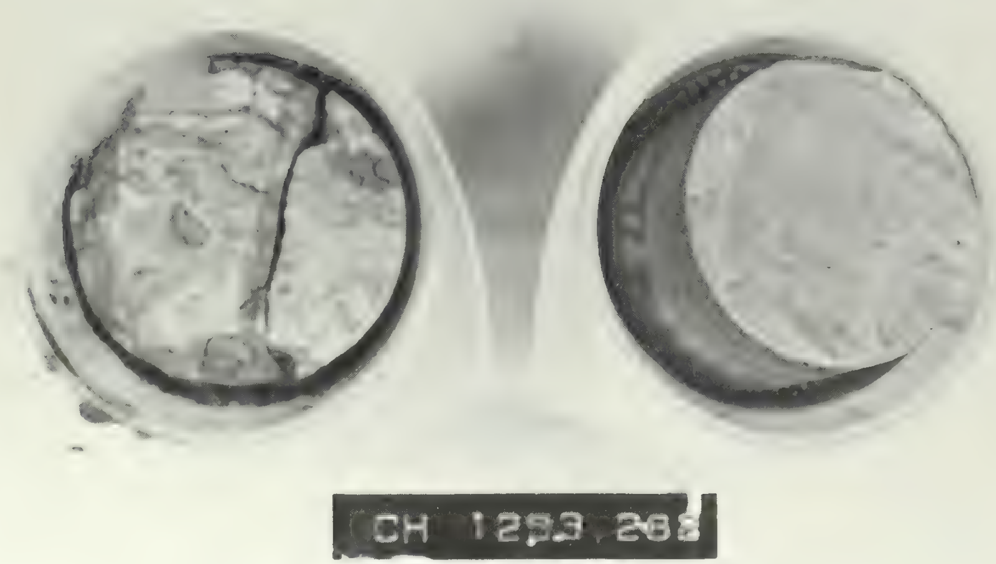


b. Condition of test specimens after weathering.

Figure 2
Results of weathering tests for shale sample 3A and siltstone sample 4A subjected to 20 laboratory weathering cycles.

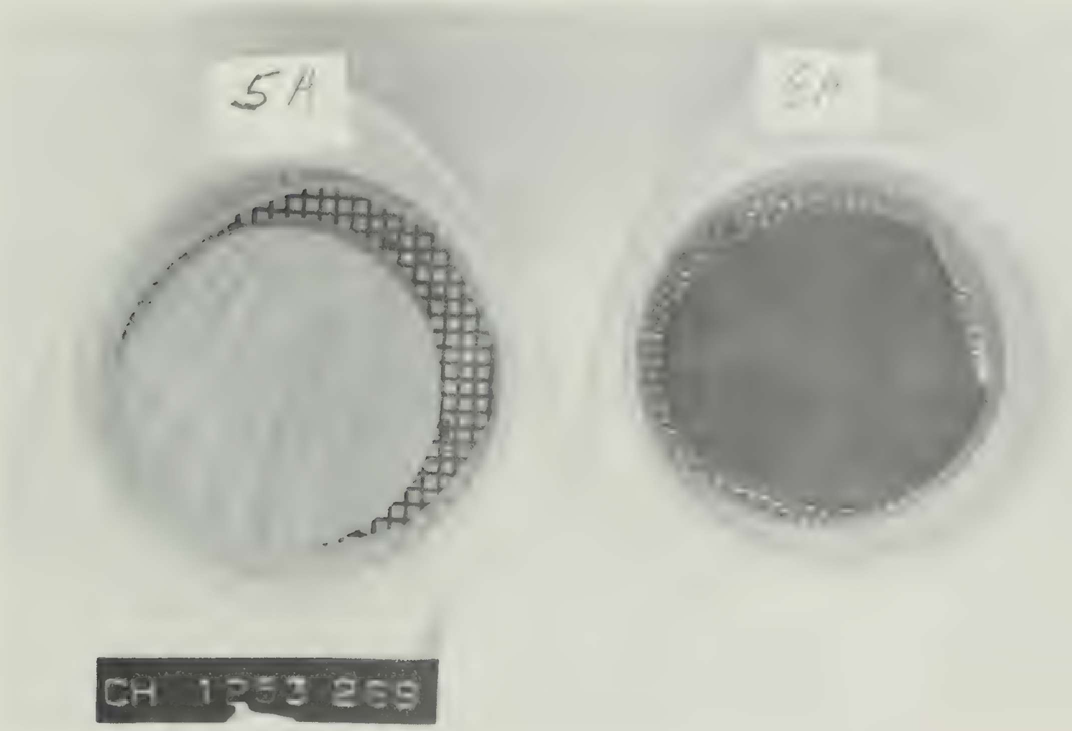


a. Original condition of test specimens.



b. Condition of test specimens after weathering.

Figure 3
Results of weathering tests for sandstone sample 5A and shale sample 6A subjected to 20 laboratory weathering cycles.

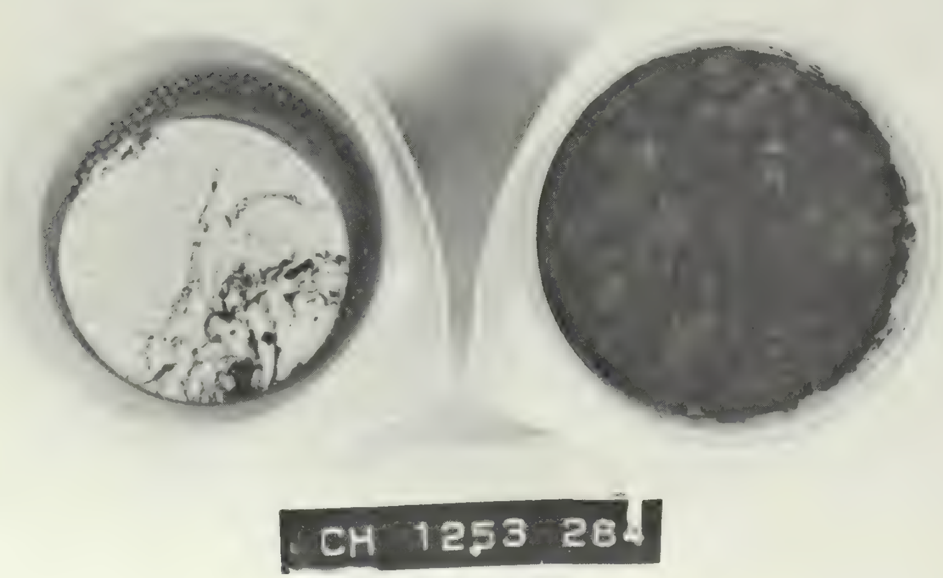


a. Original condition of test specimens.

b. Condition of test specimens after weathering.

Figure 4
Results of weathering tests for sandstone sample 7A and siltstone sample 8A subjected to 20 laboratory weathering cycles.

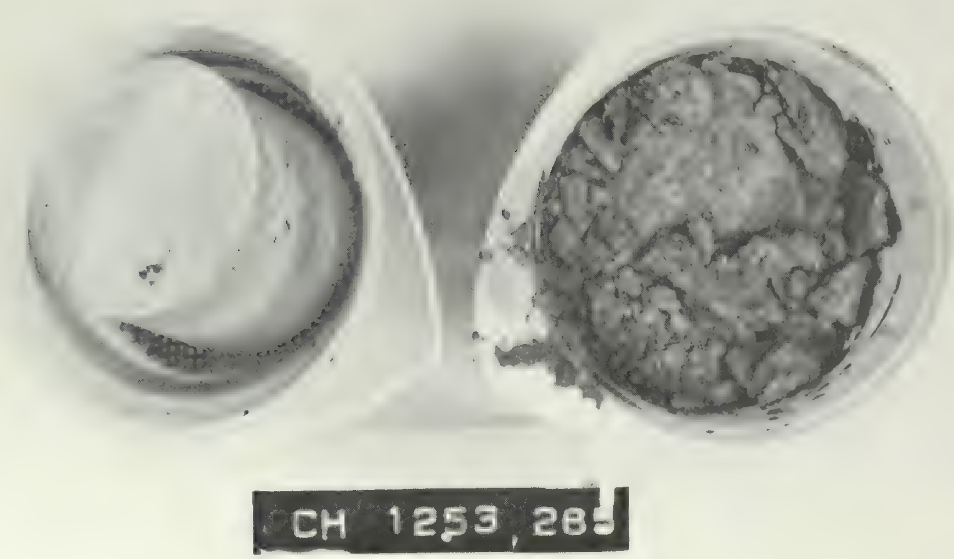
a. Original condition of test specimens.



b. Condition of test specimens after weathering.

Figure 5
Results of weathering tests for sandstone sample 9A and shale sample 10A subjected to 20 laboratory weathering cycles.

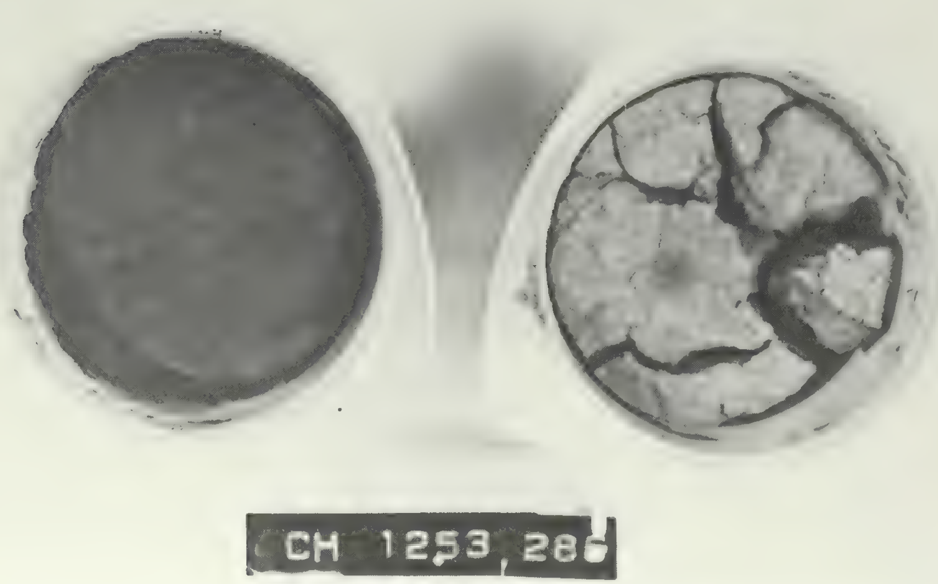
a. Original condition of test specimens.



b. Condition of test specimens after weathering.

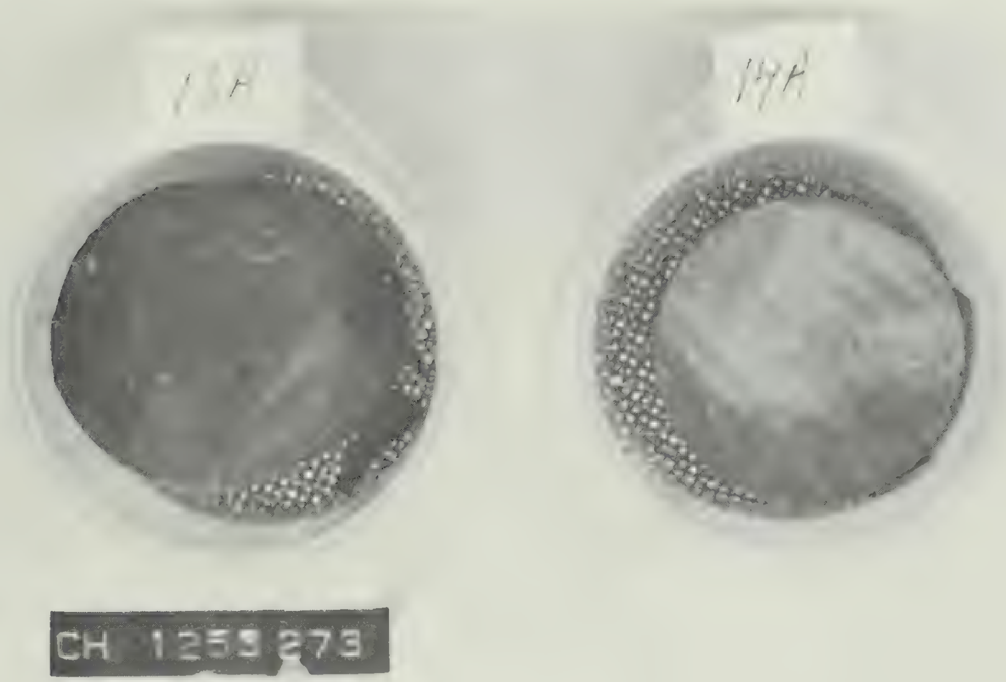
Figure 6
Results of weathering tests for siltstone sample 11A and sand-stone sample 12A subjected to 20 laboratory weathering cycles.

a. Original condition of test specimens.



b. Condition of test specimens after weathering.

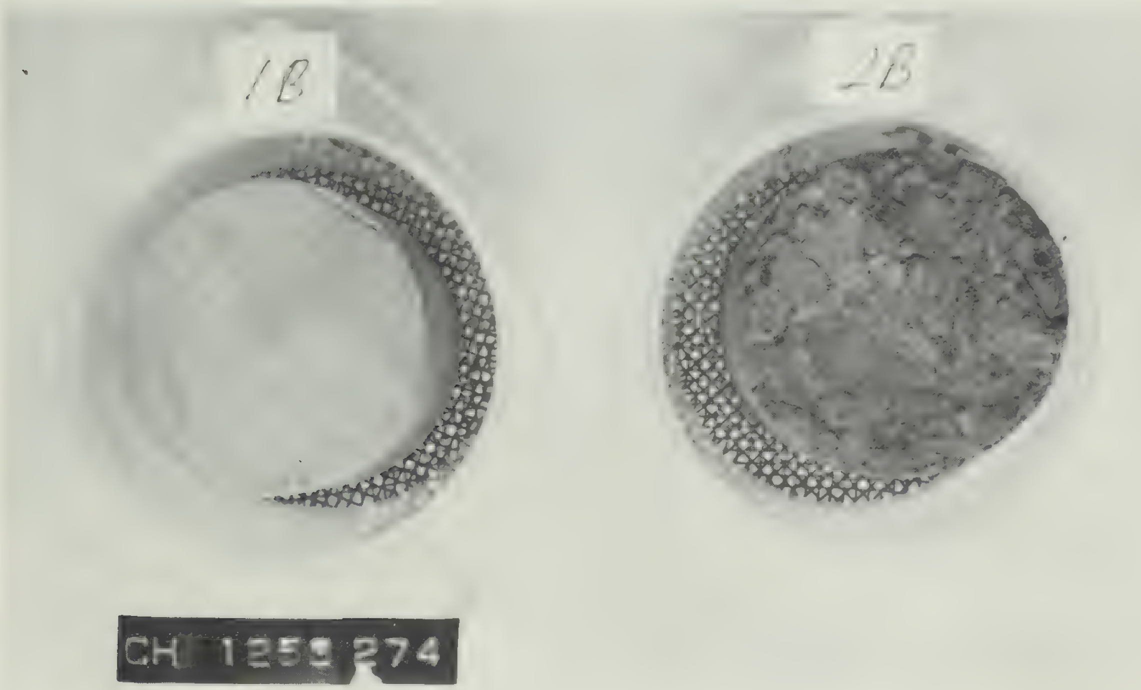
Figure 7
Results of weathering tests for shale sample 13A and siltstone sample 14A subjected to 20 laboratory weathering cycles.



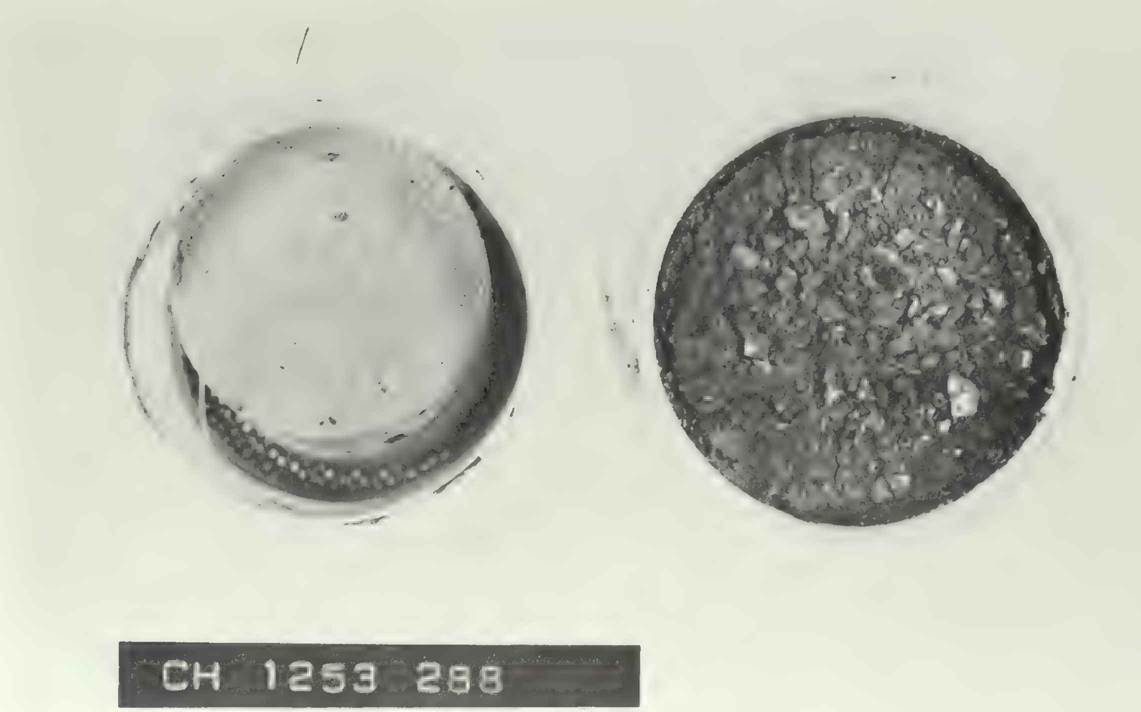
a. Original condition of test specimens.

b. Condition of test specimens after weathering.

Figure 8
Results of weathering tests for sandstone sample 1B and siltstone sample 2B subjected to 1 year of outdoor exposure.



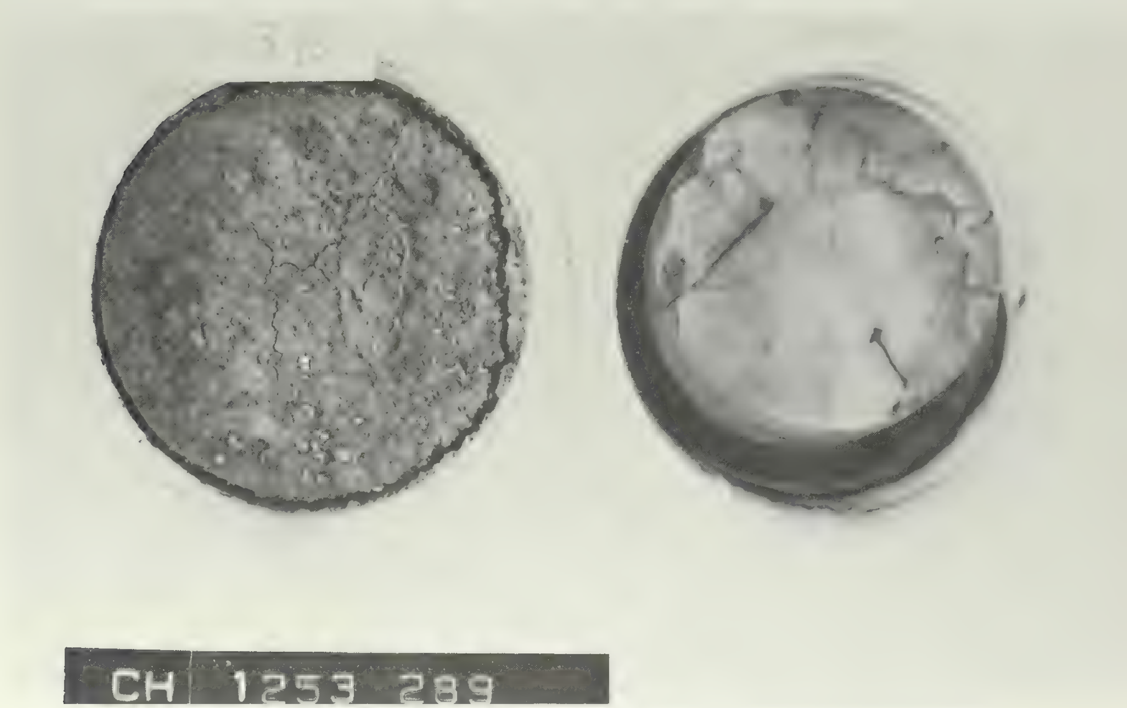
a. Original condition of test specimens.



b. Condition of test specimens after weathering.

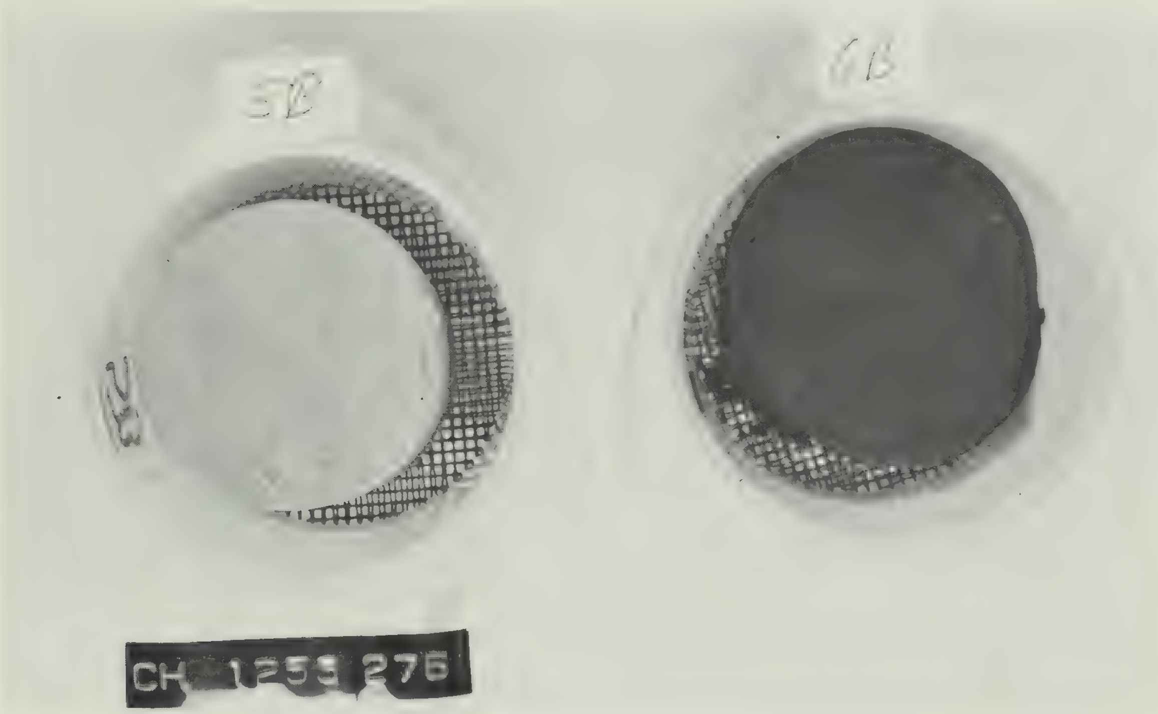
Figure 9
Results of weathering tests for shale sample 3B and siltstone sample 4B subjected to 1 year of outdoor exposure.

a. Original condition of test specimens.

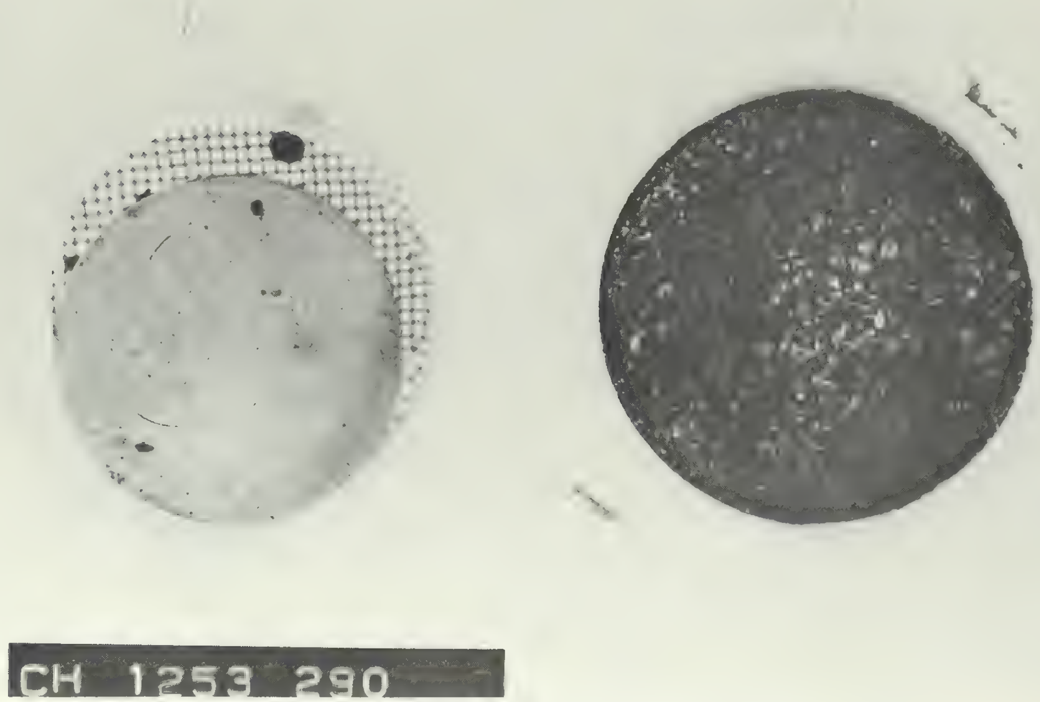


b. Condition of test specimens after weathering.

Figure 10
Results of weathering tests for sandstone sample 5B and shale sample 6B subjected to 1 year of outdoor exposure.



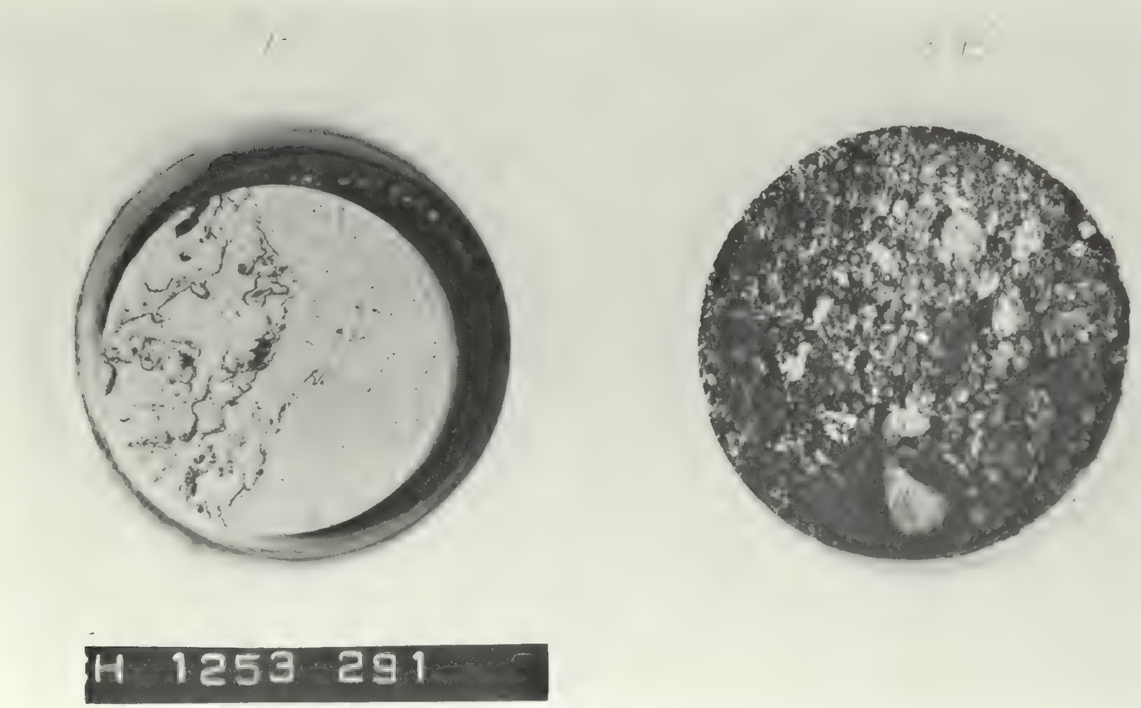
a. Original condition of test specimens.



b. Condition of test specimens after weathering.

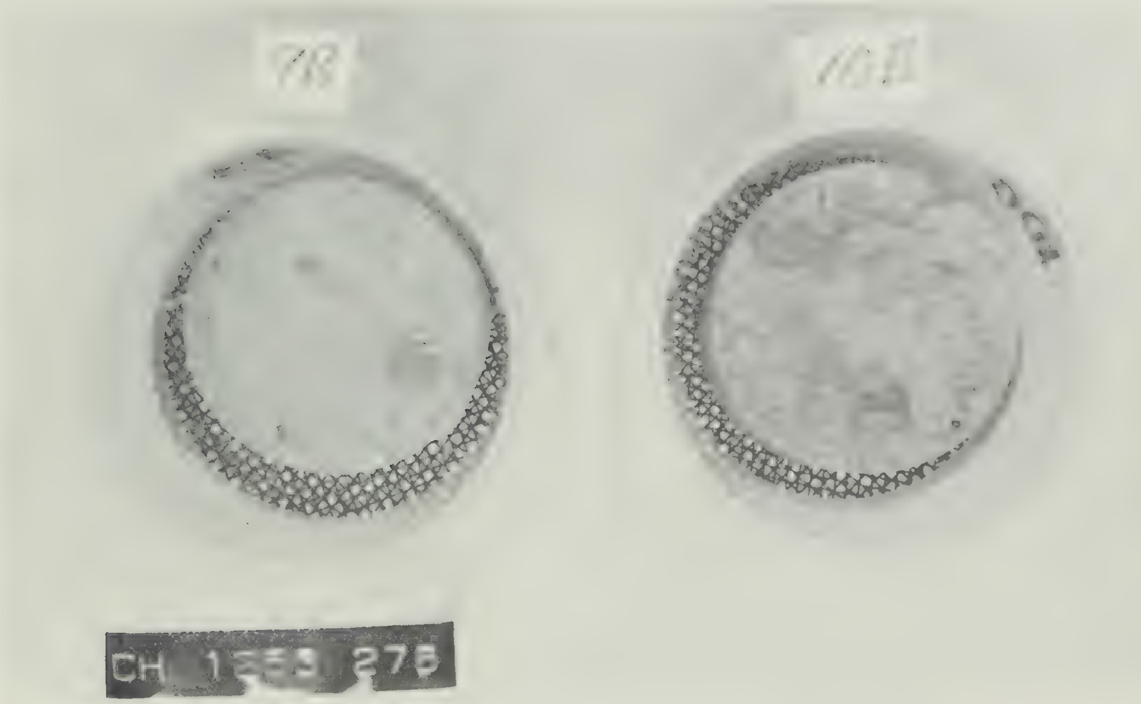
Figure 11
Results of weathering tests for sandstone sample 7B and silt-stone sample 8B subjected to 1 year of outdoor exposure.

a. Original condition of test specimens.



b. Condition of test specimens after weathering.

Figure 12
Results of weathering tests for sandstone sample 9B and shale sample 10B subjected to 1 year of outdoor exposure.

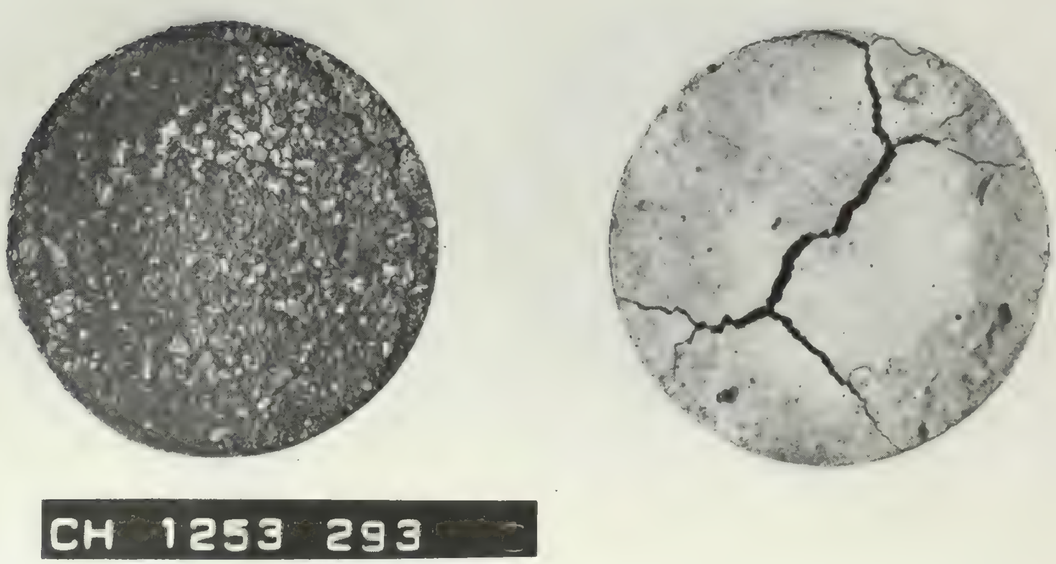


a. Original condition of test specimens.

b. Condition of test specimens after weathering.

Figure 13
Results of weathering tests for siltstone sample 11B and sandstone sample 12B subjected to 1 year of outdoor exposure.

a. Original condition of test specimens.



b. Condition of test specimens after weathering.

Figure 14
Results of weathering tests for shale sample 13B and siltstone sample 14B subjected to 1 year of outdoor exposure.

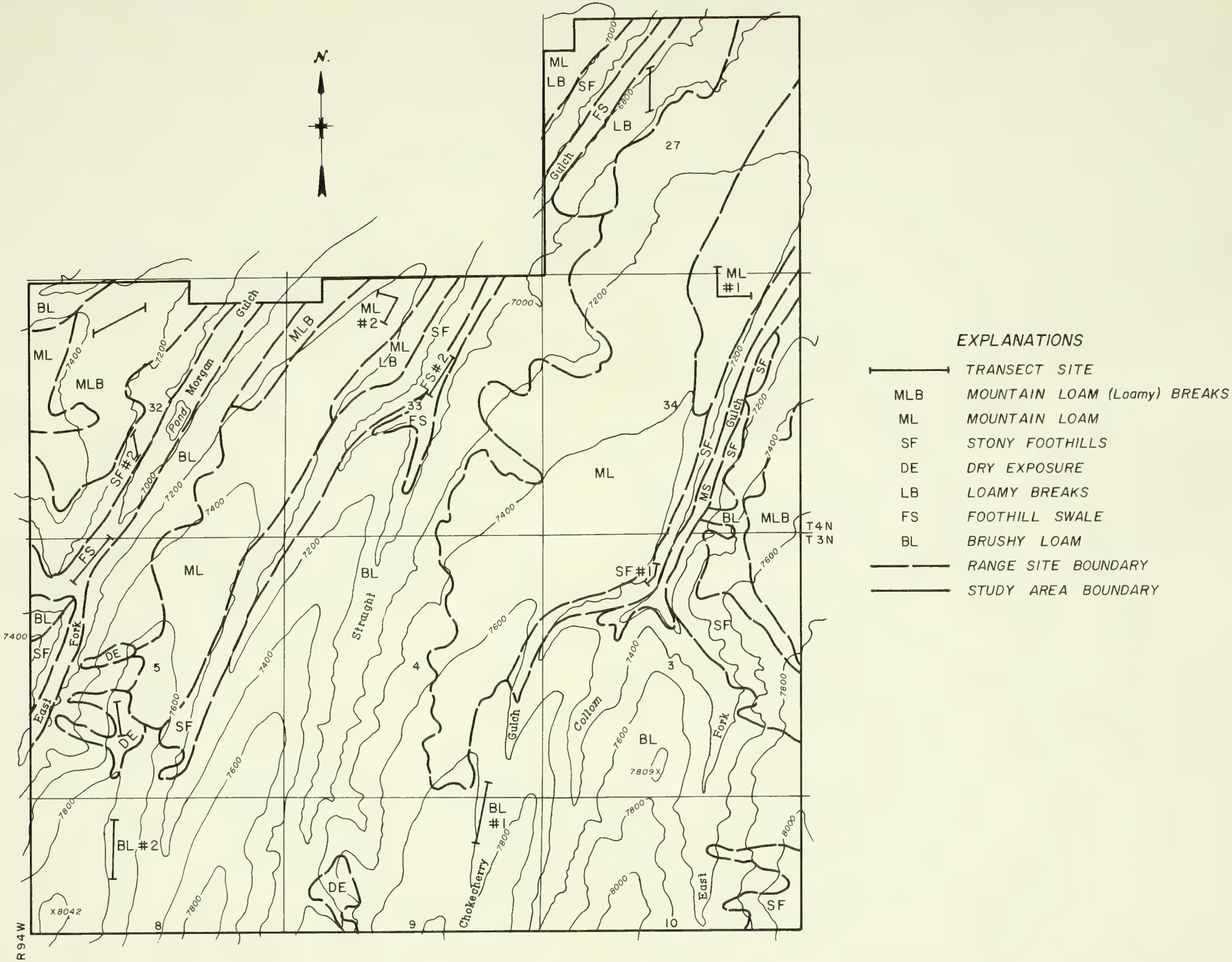
a. Original condition of test specimens.

b. Condition of test specimens after weathering.

APPENDIX F

VEGETATION

Prepared by
United States Department of the Interior
Bureau of Land Management
District Office
Craig, Colo.


N.
EXPLANATIONS
TRANSECT SITE
MLB MOUNTAIN LOAM (Loamy) BREAKS
ML MOUNTAIN LOAM
SF STONY FOOTHILLS
DE DRY EXPOSURE
LB LOAMY BREAKS
FS FOOTHILL SWALE
BL BRUSHY LOAM
RANGE SITE BOUNDARY
STUDY AREA BOUNDARY
T4N
T3N
R94W
Morgan Gulch
Pond
East Fork
Straight
Gulch
Collom
Chokecherry
ML #1
ML #2
SF #1
SF #2
FS #2
BL #1
BL #2
27
32
33
34
3
4
5
8
9
10
7809X
X8042

RANGE SITES

Table 1
Percent cover by component
as transected within each range site

Range site and transect	Bare soil	Mulch	Rock	Grass	Forbs	Shrubs	Total vegetation
Foothill Swale							
Morgan Gulch	1.33	24.00	0	24.67	30.00	20.00	74.67
Straight Gulch	17.00	40.33	1.33	24.33	6.00	11.00	41.33
Stony Foothill							
Collom Gulch	33.67	11.33	31.00	4.67	.33	19.00	24.00
Morgan Gulch	25.00	20.00	27.00	6.00	2.00	20.00	28.00
Loamy Breaks							
Straight Gulch	16.67	23.33	16.67	5.00	7.00	31.33	43.33
Mountain Loam							
No. 1	22.00	35.67	.33	5.33	10.00	26.67	42.00
No. 2	8.67	53.67	0	2.67	9.33	25.67	37.67
No. 3	9.00	47.33	0	4.33	6.33	33.00	43.67
Dry Exposure	35.00	32.00	11.33	11.67	6.67	3.33	21.67
Brushy Loam							
No. 1	6.67	31.00	.33	2.00	8.67	51.33	62.00
No. 2	10.33	29.00	.33	8.67	13.67	38.00	60.34

Table 2
Yield and percent cover by component as transected--
percent composition as transected within each range site

Range site and transect	Grass	Forb	Shrub	Total	Potential of native range sites	Percent composition of Grass	Percent composition of Forbs	Percent composition of Shrubs	Ecological seral-stage rating
Foothill Swale									
Morgan Gulch									
Yield1/	1,339.20	804.00	421.20	2,564.40	1,000 to 3,000	52.22	31.35	16.42	46.00
Cover2/	24.67	30.00	20.00	74.67					
Straight Gulch									
Yield1/	1,302.40	64.70	805.00	2,172.10	1,000 to 3,000	59.96	2.98	37.06	50.40
Cover2/	24.33	6.00	11.00	41.33					
Stony Foothill									
Collom Gulch									
Yield1/	124.70	11.60	928.80	1,065.10	400 to 800	11.71	1.09	87.20	26.80
Cover2/	4.67	.33	19.00	24.00					
Morgan Gulch									
Yield1/	259.90	98.00	514.40	872.30	400 to 800	29.79	11.23	58.97	58.40
Cover2/	6.00	2.00	20.00	28.00					
Loamy Breaks									
Straight Gulch									
Yield1/	208.20	360.70	309.30	878.20	400 to 800	23.71	41.07	35.22	58.00
Cover2/	5.00	7.00	31.33	43.33					
Mountain Loam									
No. 1									
Yield1/	208.10	383.30	945.80	1,537.20	1,200 to 1,800	13.54	24.93	61.53	17.55
Cover2/	5.33	10.00	26.67	42.00					
No. 2									
Yield1/	120.60	339.50	333.70	793.80	1,200 to 1,800	15.19	42.77	42.04	29.46
Cover2/	2.67	9.33	25.67	37.67					
No. 3									
Yield1/	106.60	284.40	707.60	1,098.60	1,200 to 1,800	9.70	25.89	64.41	26.00
Cover2/	4.33	6.33	33.00	43.67					
Dry Exposure									
Yield1/	346.90	403.70	40.40	791.00	400 to 500	43.86	51.04	5.11	32.50
Cover2/	11.67	6.67	3.33	21.67					
Brushy Loam									
No. 1									
Yield1/	60.30	197.10	734.50	991.90	1,500 to 3,000	6.08	19.87	74.05	49.50
Cover2/	2.00	8.67	51.33	62.00					
No. 2									
Yield1/	253.80	362.60	397.00	1,013.40	1,500 to 3,000	25.04	35.78	39.18	43.90
Cover2/	8.67	13.67	38.00	60.34					

1/ Reduction by weight.
2/ Percent.

Table 3
Species list and yield for grass as represented
by transect data within each range site and transect

Grasslike species	Foothill Swale: Morgan Gulch	Foothill Swale: Straight Gulch	Stony Foothill: Collom Gulch	Stony Foothill: Morgan Gulch	Loamy Breaks: Straight Gulch	Mountain Loam: No. 1	Mountain Loam: No. 2	Mountain Loam: No. 3	Dry Exposures	Brushy Loam: No. 1	Brushy Loam: No. 2
Agropyron											
cristatum		9.0									
dasystachyum							67.2				
inerme		3.4									
riparium	94.3				6.4	29.0	2.3	56.3	21.5		
saxicola								6.0			
smithii	159.0	641.5	7.0	24.8	.5	28.0	6.4	4.0	4.8		
spicatum	9.1		78.1	147.1	20.1				173.3		
trachycaulum	212.0							.8		30.9	23.3
Annual brome											.7
Bromus											
carinatus	2.5										
marginatus	14.0							.7		11.4	13.0
tectorum	4.3	32.0	1.7	11.9		22.7	.9				
Carex geyeri										14.7	71.3
Elymus											
cinereus	624.1	482.6	37.0		100.8						
salina				48.5	2.3				28.0		
Koeleria cristata		21.0		4.2	8.3		3.0	3.0	19.5		
Melica bulbosa	5.6							11.0	7.3	2.5	7.5
Oryzopsis hymenoides				20.4					2.0		
Poa											
spp.								4.0			
ampla	19.0										
pratensis	191.4							5.0	1.4		48.4
juncifolia					4.9						
secunda		9.9	.9	1.0	13.5		12.8	4.5	18.9		
fendleriana				2.0	49.7		1.4				
Sitanion hystrix		99.6			1.7		11.0	11.3			
Stipa											
comata									6.0		
columbiana											3.0
lettermannii		3.5					17.0		64.2	.8	85.9
viridula	3.9										.7
Total	1/1,339.2	2/1,302.4	3/124.7	4/259.9	1/208.2	5/208.1	1/120.6	6/106.6	1/346.9	7/60.3	8/253.8

1/ Not grazed.
2/ Western wheatgrass and June grass grazed.
3/ Sheep grazed--rubber rabbitbrush, Canada thistleflowers, serviceberry, bitterbrush, and mountain mahogany.
4/ Not grazed?
5/ Grazed?
6/ Grass grazed, 5 percent (cow).
7/ Grazed (sheep).
8/ Grazed.

Table 4
Species list and yield for forbs as represented
by transect data within each range site and transect

	Foothill Swale		Stony Foothill		Loamy Breaks	Mountain Loam				Brushy Loam	
	Morgan	Straight	Collom	Morgan	Straight				Dry		
Forbs	Gulch	Gulch	Gulch	Gulch	Gulch	No. 1	No. 2	No. 3	Exposures	No. 1	No. 2
Achillea lanulosa	45.3	6.5			13.0		1.3			18.2	17.5
Allium spp.	1.4		1.6		3.2		11.6	7.0	6.0		6.0
Androsace spp.								4.2		3.0	
Antennaria spp.									1.3		
Aster											
hesperius	396.7	29.7						.4			
			1.8			2.5		1.5			8.3
fendlerii				2.4	.8						
Artemisia ludoviciana		4.0		13.0							
Astragalus											
spp.	22.0				.5	70.6		.5	30.2		56.0
convallarius					77.6						
Agastache urticifolia											5.4
Annual forbs		1.5				12.5	.5				33.3
Balsamorrhiza sagittata					149.8		65.5	157.8	30.9		10.0
Bidens spp.1/								3.3		23.1	66.6
Cardaria draba	182.9	1.2									
Chaenactis douglasii				1.2					1.0		
Cirsium											
spp.				9.6			12.0				
arvense	138.0		1.0					3.2	94.4		
Cleome serrulata		.4									
Collomia spp.	2.8				3.0	3.0	3.2	7.0		8.4	1.4
Comandra umbellata				2.0				1.5	16.9		
Cordylanthus ramosus					4.0	261.9	90.7				
Composite2/										75.4	25.8
Descurainia						.8					
Epilobium				3.5							
Erigeron											
engelmannii		.5									
spp.					4.2		4.0		6.3		
Eriogonum									32.0		
Haplopappus acaulis					53.5				128.1		
Hedysarum boreale					17.0						
Lathyrus										14.0	16.3
Lily family spp.									2.0		.6
Linum lewisii											
Lomatium spp.								2.0	1.0		
Lupinus											
arboreus (silver)						5.0		14.8			104.0
					18.0		130.3	39.1		13.0	
ammophilus (green)						13.7					
Mustard			4.2	6.5		.8			13.6		
Penstemon spp.					.3				2.8		
Mint					2.5						
Phlox											
hoodii											
longifolia	1.4	.8	1.4	11.3	4.5		9.6	26.9	11.2	4.3	5.4
Physaria didymocarpa				2.6							
Polygonum (knotweed)							2.0	2.5		5.5	
Unknown forbs			1.6	4.5				1.0		23.8	
Senecio											
spp.				3.5	6.6		6.6	2.2	8.4		
multilobatus ?					1.2			8.3			
Sphaeralcea coccinea		20.1		37.9		8.7	1.2		16.6		
Traxacum officinale	9.6					1.0					
Thlaspi (pennycress)	3.9										
Trifolium					1.0	2.8	1.0		1.0		
Tragopogon dubius								1.2			
Viguiera multiflora										8.4	6.0
Total	804.0	64.7	11.6	98.0	360.7	383.3	339.5	284.4	403.7	197.1	362.6

1/ Unknown No. 1.
2/ Unknown No. 2.

Table 5
Species list and yield for shrubs as represented
by transect data within each range site and transect

Shrubs	Foothill Swale		Stony Foothill		Loamy Breaks	Mountain Loam			Dry	Brushy Loam	
(lbs/acre)	Morgan Gulch	Straight Gulch	Collom Gulch	Morgan Gulch	Straight Gulch	No. 1	No. 2	No. 3	Exposures	No. 1	No. 2
Amelanchier alnifolia		1.0	390.9	67.1	16.8					204.0	8.5
Artemisia tridentata	40.3	151.6	480.1	9.8	215.2	932.0	307.6	564.2	19.3		
Cercocarpus montanus				152.0							
Ceratoides lanata		9.6									
Chrysothamnus											
nauseousus	335.3	639.8	29.9	169.5			26.1				
viscidiflorus				51.0	25.7	2.8		143.4	1.8		
Gutierrezia sarothrae					.4	11.0					
Mahonia repens				19.0	14.0						3.8
Prunus virginiana										29.1	
Quercus gambelii				21.0						235.6	37.0
Rosa spp.										12.5	
Symphoricarpos albus	45.6	3.0	27.9	25.0	35.0				3.3	253.3	347.7
Tetradymia canescens					2.2				10.0		
Total	421.2	805.0	928.8	514.4	309.3	945.8	333.7	707.6	40.4	734.5	397.0

APPENDIX G

SURFACE WATER HYDROLOGY OF THE COAL HYDROLOGY STUDY SITE IN COLLOM GULCH, NORTHWESTERN COLORADO

Prepared by
United States Department of the Interior
Geological Survey
Water Resources Division
Denver, Colo.

APPENDIX G

SURFACE WATER HYDROLOGY OF THE COAL HYDROLOGY STUDY SITE IN COLLOM GULCH, NORTHWESTERN COLORADO

General

The Collom Gulch Coal Hydrology study site is located south of the Yampa River and about 18 miles north of Meeker, Colo. (Figure 1). The study site is in the central part of the Morgan Gulch and Collom Gulch watersheds. The area of the Morgan Gulch watershed is about 26 square miles, and the area of the Collom Gulch watershed is about 14 square miles. Both drain the Danforth Hills coal region in a northeasterly direction. The elevation ranges from about 6,400 to 8,400 feet and the predominant vegetation types are sagebrush at the lower elevations, oakbrush at the mid-elevations, and aspen on north-facing slopes and higher elevations. Average annual precipitation, which falls mostly as snow, is about 16 inches. The perennial streams are sustained by discharge from springs with the snowmelt peak generally occurring in April or May and infrequent runoff from rainfall occurring in late summer and early fall.

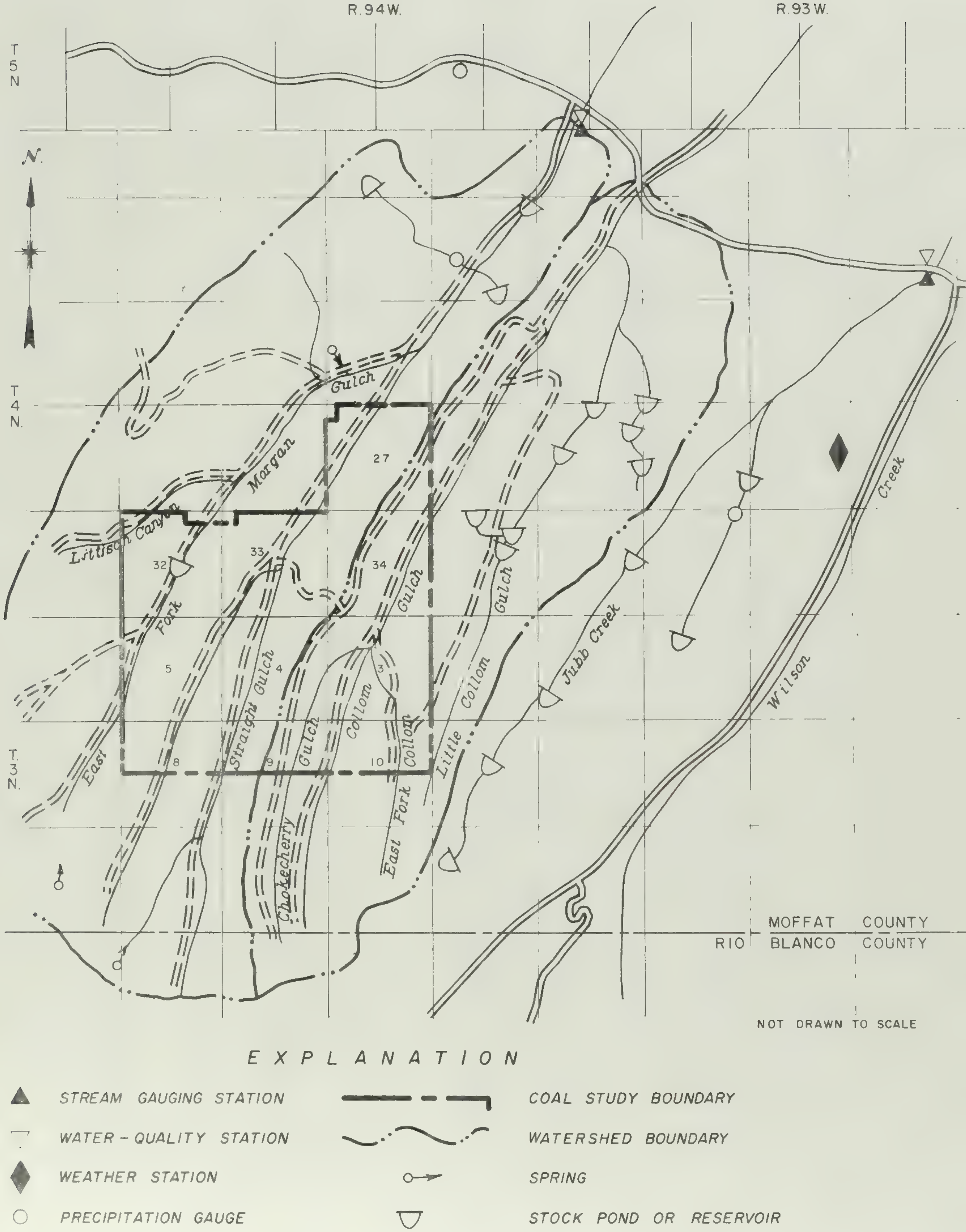
A streamflow gage was installed on Morgan Gulch in September 1980; and in August 1981, a V-notch weir was installed to improve the control section. Jubb Creek, Wilson Creek, and Taylor Creek are just east of Morgan Gulch (Figure 1) and have been gaged since about 1974. Water quality samples have been collected at all of the above stations. In addition, water quality samples have been collected from Jessie Gulch, Maudlin Gulch, and Collom Gulch in 1981.

A table of available discharge data is included in Attachment A. A few instantaneous discharge measurements for Collom Gulch are included with the water quality data in Attachment B. As expected, discharge from Collom Gulch is considerably less than discharge from Morgan Gulch.

A U.S. Geological Survey weather station in the Wilson Creek drainage has been monitoring precipitation, temperature, windspeed and direction, solar radiation, and soil temperature since 1977. A precipitation gage also is located in the headwaters of Wilson Creek. Information from these stations was used in modeling discharge in Morgan Gulch.

Flow in both Collom and Morgan Gulches is somewhat affected by numerous stock ponds and beaver ponds. The effects are difficult to quantify, but the ponds probably decrease runoff peaks and extend the duration of peak flow recession to a limited extent.

Total monthly discharge of Morgan Gulch measured during water year 1980 is shown by the shaded bar graph (Figure 2). Water year 1980 was unusually dry. The total monthly discharge simulated by the U.S. Geological Survey Precipitation-Runoff Modeling System (Leavesley and others, 1981) for water year 1979 (Figure 2) is more typical of the discharge volumes one would normally expect in Morgan Gulch.



COLLOM GULCH STUDY SITE

LOCATION OF STUDY AREA

FIGURE 1

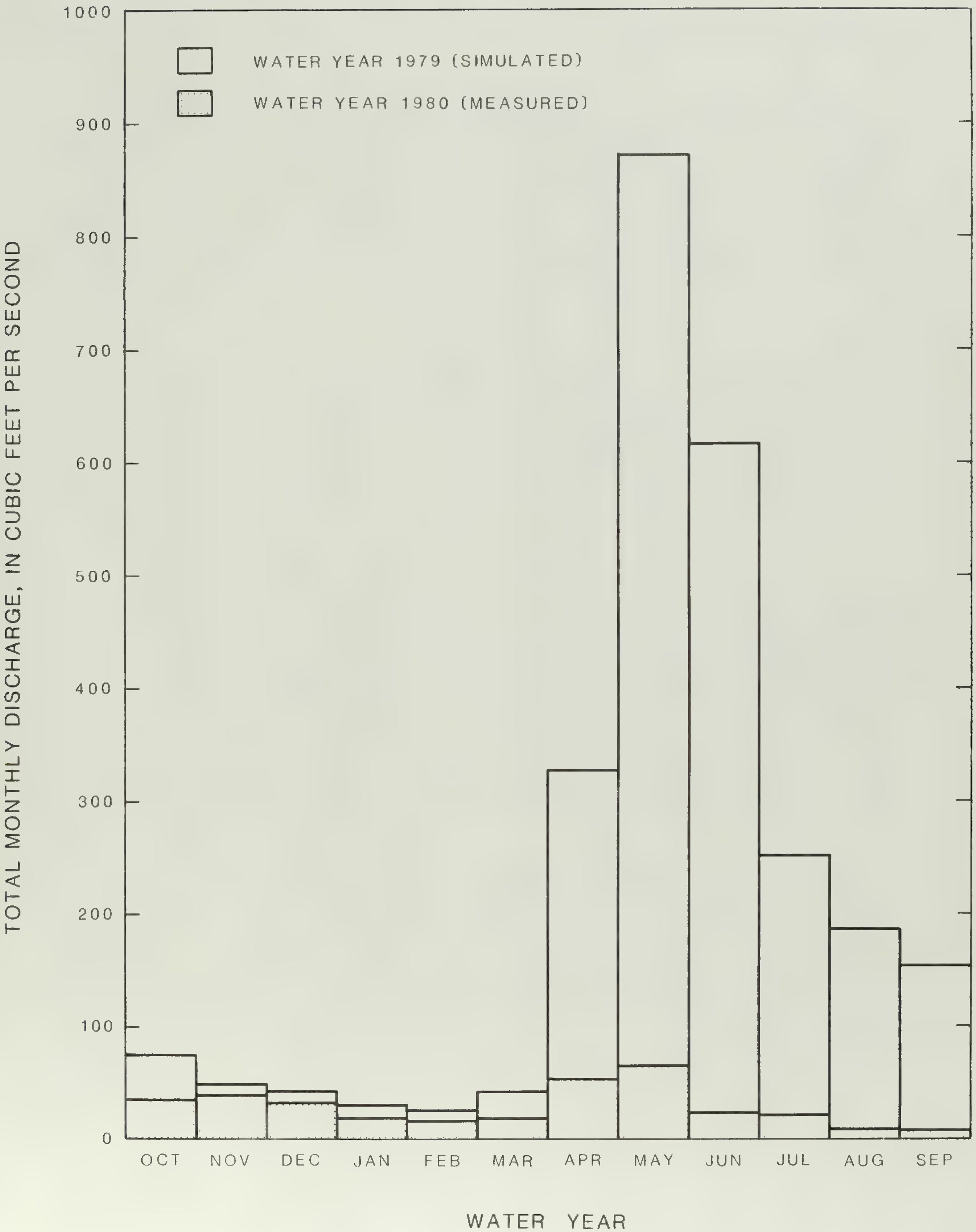


FIGURE 2: **Total monthly discharge for Morgan Gulch as simulated for water year 1979 and measured during water year 1980.**

Floodflows for Collom and Morgan Gulches were estimated using the technique outlined in McCain and Jarrett (1976). Discharge and depth for the 10-, 50-, 100-, and 500-year recurrence intervals are presented in Table 1. Both Collom and Morgan Gulches are considered to be "mixed population flood areas" because they are located in the Northern Plateau Region and the Mountain Region as described in the report by McCain and Jarrett (1976). Although this technique is the best available at the present time (1982), the equations used to estimate floods in the mixed population or transition areas could be more reliable.

Table 1
Flood discharge and depth
for Collom and Morgan Gulches

	Collom Gulch		Morgan Gulch	
Recurrence interval (years)	Discharge (cubic feet per second)	Depth (feet)	Discharge (cubic feet per second)	Depth (feet)
10	240	3.6	350	4.3
50	410	3.9	630	4.6
100	540	4.1	770	4.8
500	760	4.3	1,050	5.1

Tables of available water quality data for Morgan and Collom Gulches are included in Attachment B. Both streams contain magnesium sulfate water. Morgan Gulch has greater concentrations of dissolved solids than does Collom Gulch. The average dissolved solids concentration in Morgan Gulch is more than 1,000 milligrams per liter, whereas that for Collom Gulch is about 600 milligrams per liter. The only water quality constituent that exceeds the U.S. Environmental Protection Agency's (1975, 1976) Recommended Drinking Water Standards is sulfate in Morgan Gulch. All other constituents listed in the table in Attachment B meet drinking water standards.

Only a small part of the heavy metals in Morgan and Collom Gulches is dissolved. Most of the heavy metals are associated with the suspended material. For example, the average concentration of total recoverable iron in Morgan Gulch is 459 micrograms per liter, and the average concentration of dissolved iron is 21 micrograms per liter or about 5 percent of the total. This balance between the suspended and dissolved constituents with only a small part of the total metals in the dissolved state should be expected with the pH of 7.9 to 8.5 found in Morgan and Collom Gulches. If the pH were lowered, greater concentrations of dissolved metals could be expected.

Potential Impacts

The impacts of surface coal mining on water resources in Morgan and Collom Gulches will depend upon the type of mining and the area disturbed. An example of mining impacts on stream discharge of Morgan Gulch was simulated with the U.S. Geological Survey Precipitation-Runoff Modeling System (Leavesley and others, 1981).

The model was initially calibrated using the first 7 months of discharge data for water year 1981 from Morgan Gulch. The following assumptions were then used to make several changes to the calibrated input variables of the model to simulate hypothetical postmining conditions.

1. The method of mining will be similar to that used at the ColoWyo Mine in the Taylor Creek watershed.

2. About 50 percent of the watershed will be mined.

3. The land surface will be returned to its natural contours.

4. The vegetation in the reclaimed area will be converted to grass.

5. The ground water routing procedure was modified to reflect additional ground water storage in the reclaimed area.

Four months of calibrated discharge for Morgan Gulch are compared to the predicted discharge after mining and reclamation for a hypothetical case using the above assumptions (Figure 3). The following data are simulated from the model. After mining, spring runoff will begin and peak earlier. This earlier peak probably can be attributed to the change in vegetation type from trees and shrubs to grass, which would increase direct exposure to the sun and result in earlier snowmelt. The peak is lower because more water is able to move into the newly formed ground water system created by the reclaimed area where it eventually results in higher baseflow. As shown by the data in Table 2, total runoff from Morgan Gulch will almost double after mining. This almost twofold increase in runoff results from a 15 percent decrease in evapotranspiration. The data in Table 2 also show that the change in vegetation results in less interception loss and more than a 0.5-inch increase in net precipitation, which also contributes to the increased runoff. The decrease in evapotranspiration and interception results from a change in vegetation type and from the reclaimed area delivering water quickly to subsurface storage. Impacts of mining on Collom Gulch discharge probably would be similar to those described above for Morgan Gulch.

Table 2
Water budget for Morgan Gulch
before and after surface coal mining as predicted by the
Precipitation-Runoff Modeling System for water year 1980

Water budget component	Calibrated discharge		Predicted postmining discharge	
	Inches	Percent	Inches	Percent
Net precipitation[1/]	23.98	100	24.65	100
Evapotranspiration	19.95	83	16.77	68
Runoff	3.62	15	6.97	28
Change in ground water storage	.28	1	.87	3.5
Change in soil moisture	.13	1	.04	.5

1/ Total precipitation-interception.

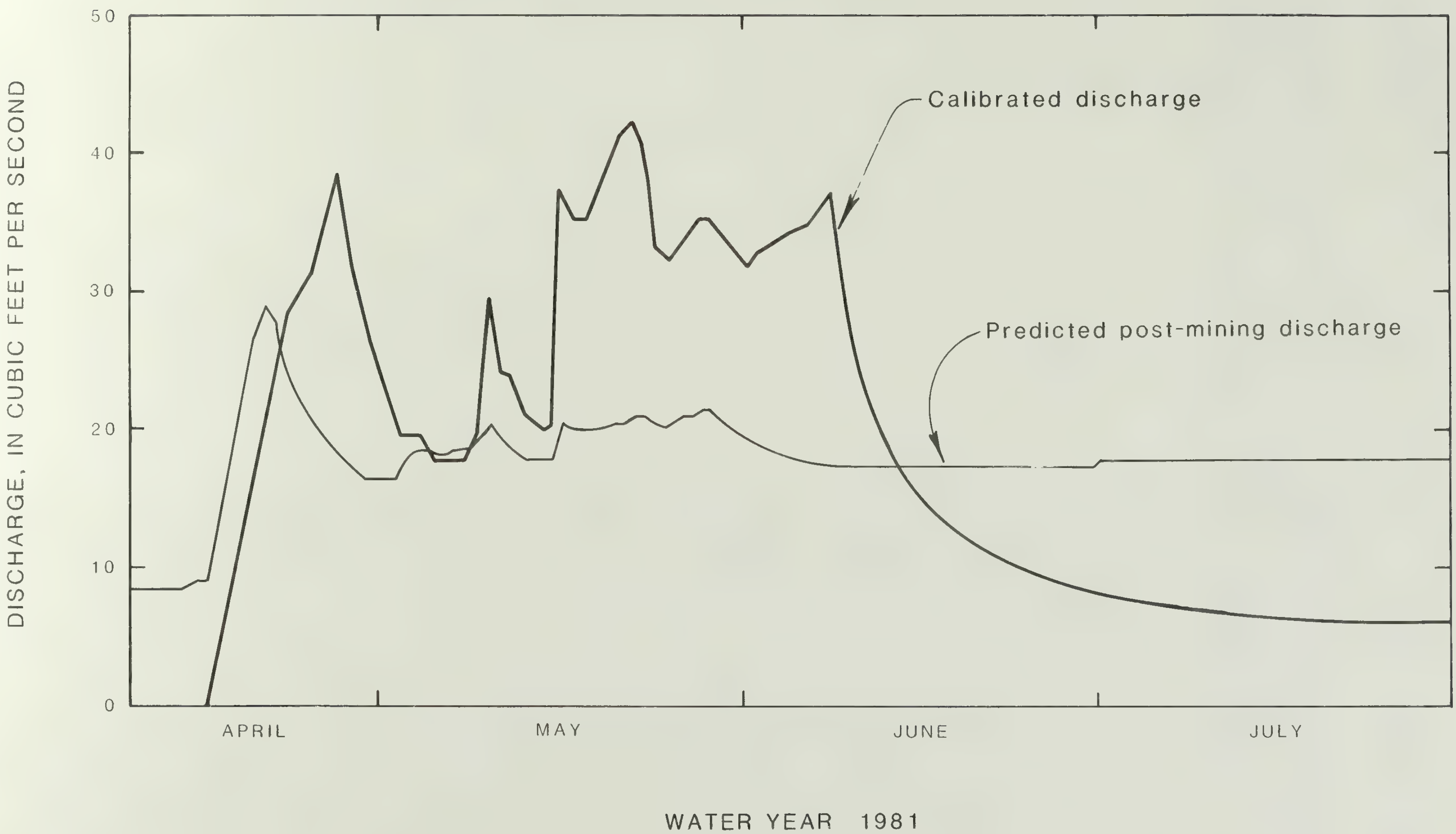


FIGURE 3: Comparison of calibrated discharge for Morgan Gulch with predicted discharge after mining and reclamation.

Although the direction of change between mined and unmined conditions is probably correct, the actual quantities of water in each water balance category could be significantly different from those predicted based on the previous assumptions. Changes on specific mine plans can alter quantities of water in individual water categories significantly.

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2. McCain, J. F. and R. D. Jarrett. 1976. Manual for Estimating Flood Characteristics of Natural-Flow Streams in Colorado. Colorado Water Conservation Board, Technical Manual No. 1, 68 pages.

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ATTACHMENTS

ATTACHMENT A

DISCHARGE DATA FOR MORGAN GULCH

Discharge data for Morgan Gulch near Axial, Colo.
Station 09250700
Water year October 1980 to September 1981
(Unit--cfs)1/

Day	October	November	December	January	February	March	April	May	June	July	August	September
1	0.59	1.5	1.4	0.80	0.60	1.1	1.5	1.5	1.4	0.44	0.48	0.12
2	.59		1.4	.90		1.2	2.4	1.6	1.2	.84	.46	.10
3	.59		1.5	1.1		1.2	2.2	1.7	1.5	.71	.44	.12
4	.66		1.4	1.2		1.2	2.0	1.8	1.5	.57	.43	.09
5	.66		1.4	1.1		1.5	1.9	1.9	1.2	.54	.43	.11
6	.76	1.5	1.3	.90		1.4	1.9	2.4	1.1	.94	.41	.13
7	.74	1.4	1.2	.80		1.4	2.0	2.1	1.1	.88	.39	.11
8	.77	1.4	1.2	.70		1.4	2.8	1.9	.91	.78	.42	.11
9	.78	1.4	1.1			1.3	2.1	1.9	.83	.77	.43	.13
10	.79	1.4				1.4	1.7	1.7	.91	.80	.44	.15
11	.81	1.5				1.4	1.9	2.1	.95	.81	.48	.12
12	.81	1.4			.60	1.3	1.5	2.1	.78	1.0	.53	.11
13	1.1				.70	1.3	1.4	1.9	.66	.92	.51	.10
14	2.0					1.3	1.4	1.6	.73	.82	.50	.09
15	1.6		1.1			1.3	1.6	1.5	.74	.74	.60	
16	1.4		1.0	.70		1.2	1.6	2.0	.69	.71	.57	
17	1.7			.60		1.2	1.7	2.5	.55	.75	.45	
18	2.0					1.3	2.0	2.2	.51	.74	.41	
19	1.8					1.7	2.0	1.8	.47	.69	.21	.09
20	1.5					1.2	1.7	2.0	.42	.57	.14	.08
21	1.4		1.0			1.3	1.8	2.8	.37	.50	.13	.09
22	1.3		.90			1.7	1.7	2.5	.35	.49	.13	
23	1.2	1.4	1.0			1.6	1.9	2.2	.33	.48	.12	
24	1.5	1.1	1.0		.70	1.6	2.3	1.9	.30	.50	.11	
25	1.6		1.3		.80	1.8	1.9	1.8	.27	.59	.11	.09
26	1.6				.90	1.6	1.7	1.7	.25	.57	.11	.10
27	1.7				1.0	2.0	1.4	1.8	.29	.65	.11	.09
28	1.7				1.1	2.0	1.2	2.2	.44	.53	.10	.09
29	1.7	1.1	1.3			1.6	1.3	1.9	.42	.48	.10	.09
30	1.7	1.4	1.1			1.6	1.3	1.5	.39	.49	.15	.09
31	1.6		.90	.60		1.8		1.6		.50	.14	
Total	38.65	40.9	35.90	22.10	19.40	44.9	53.8	60.1	21.56	20.80	10.04	3.03
Mean	1.25	1.36	1.16	.71	.69	1.45	1.79	1.94	.72	.67	.32	.10
Maximum	2.0	1.5	1.5	1.2	1.1	2.0	2.8	2.8	1.5	1.0	.60	.15
Minimum	.59	1.1	.90	.60	.60	1.1	1.2	1.5	.25	.44	.10	.08

Water year 1981: Total, 371.18; mean, 1.02; maximum, 2.8; minimum, 0.08.

1/ Mean values.

ATTACHMENT B

WATER QUALITY DATA FOR MORGAN AND COLLOM GULCHES

Statistical analysis system
Morgan Gulch near Axial, Colo.
Station 09250700

Constituent	Number of observations	Mean	Standard deviation	Minimum value	Maximum value	Standard error of mean
Temperature (°C)	10	13.13	7.76	0	22.50	2.45
Streamflow, instantaneous (cfs)	10	.83	.56	0.24	1.90	.18
Specific conductance (umhos)	11	1,527.27	80.01	1,430	1,690	24.12
Oxygen, dissolved (mg/L)	8	8.91	1.62	7.40	11.60	.57
pH (units)	10	8.26	.10	8.10	8,40	.03
pH laboratory (units)	9	8.23	.07	8.10	8.30	.02
Alkalinity field (mg/L as $CaCO_3$)	1	400		400	400	
Nitrogen, ammonia dissolved (mg/L as N)	1	0		0	0	
Nitrogen, NO_2+NO_3 dissolved (mg/L as N)	10	0.03	.03	0	0.09	.01
Phosphate, ortho, dissolved (mg/L as PO_4)	9	.08	.16	0	.49	.05
Phosphorus, total (mg/L as P)	0					
Phosphorus, ortho, dissolved (mg/L as P)	9	.03	.05	0	.16	.02
Carbon, organic total (mg/L as C)	2	8.25	1.34	7.30	9.20	.95
Carbon, organic dissolved (mg/L as C)	2	8.05	7	3.10	13	4.95
Hardness (mg/L as $CaCO_3$)	10	797	63.95	720	920	20.22
Hardness, noncarbonate (mg/L $CaCO_3$)	3	373.33	35.12	340	410	20.28
Calcium, dissolved (mg/L as Ca)	10	92.70	14.99	75	120	4.74
Magnesium, dissolved (mg/L as Mg)	10	137	8.23	130	150	2.60
Sodium, dissolved (mg/L as Na)	10	63.70	9.65	53	85	3.05
Sodium adsorption ratio	10	1.03	.24	0.80	1.60	.08
Percent sodium	10	14.70	1.89	13	19	.60
Potassium, dissolved (mg/L as K)	10	9.29	.56	8.50	10	.18
Chloride, dissolved (mg/L as Cl)	10	16.70	2.11	13	20	.67
Sulfate, dissolved (mg/L as SO_4)	10	470	42.69	430	570	13.50
Flouride, dissolved (mg/L as F)	10	0.49	.10	0.40	0.70	.03
Silica, dissolved (mg/L as SiO_2)	10	12.59	1.52	9.90	15	.48
Arsenic, dissolved (µg/L as As)	1	2		2	2	
Arsenic, suspended total (µg/L as As)	1	0		0	0	
Arsenic, total (µg/L as As)	2	1.50	.71	1	2	.50
Boron, dissolved (µg/L as B)	9	152.22	21.08	110	180	7.03
Cadmium, dissolved (µg/L as Cd)	1	1		1	1	
Cadmium, total recoverable (µg/L as Cd)	2	0.50	.71	0	1	.50
Chromium, dissolved (µg/L as Cr)	0					
Chromium, total recoverable (µg/L as Cr)	1	10		10	10	
Cobalt, dissolved (µg/L as Co)	0					
Cobalt, total recoverable (µg/L as Co)	1	1		1	1	
Copper, dissolved (µg/L as Cu)	1	1		1	1	
Copper, suspended recoverable (µg/L as Cu)	1	3		3	3	
Copper, total recoverable (µg/L as Cu)	2	5.50	2.12	4	7	1.50
Iron, suspended recoverable (µg/L as Fe)	8	451.25	464.22	140	1,500	164,13
Iron, total recoverable (µg/L as Fe)	10	583	568.23	150	1,700	179.69
Iron, dissolved (µg/L as Fe)	9	21.22	22,55	10	80	7.52
Lead, dissolved (µg/L as Pb)	2	2	1.41	1	3	1
Lead, suspended recoverable (µg/L as Pb)	2	0.50	.71	0	1	0.50
Lead, total recoverable (µg/L as Pb)	3	1	1	0	2	.58
Manganese, suspended recoverable (µg/L as Mn)	9	17.22	12.53	5	40	4.18
Manganese, total recoverable (µg/L as Mn)	10	43	19.47	20	80	6.16
Manganese, dissolved (µg/L as Mn)	9	21.33	5.22	15	30	1.74
Molybdenum, dissolved (µg/L as Mo)	1	10		10	10	
Molybdenum, total recoverable (µg/L as Mo)	1	2		2	2	
Nickel, dissolved (µg/L as Ni)	1	0		0	0	
Nickel, suspended recoverable (µg/L as Ni)	1	4		4	4	
Nickel, total recoverable (µg/L as Ni)	1	4		4	4	
Zinc, dissolved (µg/L as Zn)	2	10	0	10	10	0
Zinc, suspended recoverable (µg/L as Zn)	2	15	7.07	10	20	5
Zinc, total recoverable (µg/L as Zn)	3	26.67	5.77	20	30	3.33
Aluminum, total recoverable (µg/L as Al)	3	943.33	568.71	610	1,600	328.35
Aluminum, dissolved (µg/L as Al)	2	10	14.14	0	20	10
Aluminum, suspended recoverable (µg/L as Al)	2	605	21.21	590	620	15
Selenium, dissolved (µg/L as Se)	1	1		1	1	
Selenium, suspended recoverable (µg/L as Se)	1	0		0	0	
Selenium, total (µg/L as Se)	2	1	0	1	1	0
Solids, sum of constituents, dissolved	10	1,065.90	73.53	977	1,200	23.25
Solids, dissolved (tons per day)	10	2.43	1.70	0.69	5.39	.54
Solids, dissolved (tons per acre-foot)	10	1.45	.10	1.33	1.63	.03
Sediment, suspended sieve diameter percent finer than 0.062	2	69.70	12.87	60.60	78.80	9.10
Nitrogen, ammonia dissolved (mg/L as NH_4)	1	0		0	0	
Mercury, dissolved (µg/L as Hg)	1	0		0	0	
Mercury, suspended recoverable (µg/L as Hg)	1	0		0	0	
Mercury, total recoverable (µg/L as Hg)	2	0.05	.07	0	0.10	.05
Sediment, suspended (mg/L)	9	152.56	136.08	25	404	45.36
Sediment, discharge, suspended (tons/day)	9	.50	.62	0.02	1.70	.21
Potassium 40, dissolved (pci/L as K40)	7	6.86	,37	6.30	7.50	.14
Specific conductance laboratory (umhos)	9	1,503.33	51.23	1,420	1,590	17.08
Alkalinity laboratory (mg/L as $CaCO_3$)	9	441.11	32.96	410	510	10.99
Hardness, noncarbonate (mg/L as $CaCO_3$)	7	354.29	60.79	300	480	22.98

Water quality data
Morgan Gulch near Axial, Colo.
Station 09250700
Water year October 1979 to September 1980

	Date: September 17
Temperature (°C)	17.8
Streamflow, instantaneous (cfs)	.86
Specific conductance (umhos)	1,430
pH (units)	8.1
Alkalinity field (mg/L as	400
Nitrogen, NO_2+NO_3, dissolved (mg/L as N)	0
Hardness (mg/L as $CaCO_3$)	740
Hardness, noncarbonate (mg/L as $CaCO_3$)	340
Calcium, dissolved (mg/L as Ca)	80
Magnesium, dissolved (mg/L as Mg)	130
Sodium, dissolved (mg/L as Na)	53
Sodium adsorption ratio	0.9
Percent sodium	13
Potassium, dissolved (mg/L as K)	10
Chloride, dissolved (mg/L as Cl)	19
Sulfate, dissolved (mg/L as SO_4)	430
Fluoride, dissolved (mg/L as F)	0.5
Silica, dissolved (mg/L as SiO_2)	14
Sum of constituents, dissolved (mg/L)	977
Solids, dissolved (tons per day)	2.3
Solids, dissolved (tons per acre-foot)	1.3

Water quality data
Morgan Gulch near Axial, Colo.
Station 09250700
Water year October 1980 to September 1981

Constituent	January 21	February 24	April 1	April 28	May 29	June 25	July 15	August 7	September 17
Temperature (°C)	0	0	14	21.5	13.5	16	15	22.5	11
Streamflow, instantaneous (cfs)	0.62	0.68	1.6	1.2	1.9	0.27	0.59	.38	0.24
Specific conductance (umhos)	1,690	1,480	1,550	1,550	1,520	1,500	1,500	1,450	1,480
Oxygen, dissolved (mg/L)	11	11.6	8.5	7.4	8.8		7.5	7.4	9.1
pH (units)	8.2	8.3	8.4	8.3	8.2	8.2	8.2	8.4	8.3
pH laboratory (units)	8.1	8.2	8.3	8.2	8.3	8.2	8.2	8.3	8.3
Nitrogen, ammonia, dissolved (mg/L as N)	0								
Nitrogen, NO_2+NO_3, dissolved (mg/L as N)	0	0	.09	.03	.05	.03	.02	0	.03
Phosphate, ortho, dissolved (mg/L as PO_4)	0	0	0	0	.49	.09	.09	0	.03
Phophorus, ortho, dissolved (mg/L as P)	0	0	0	0	.160	.030	.030	0	.010
Carbon, organic total (mg/L as C)				9.2			7.3		
Carbon, organic, dissolved (mg/L as C)				13			3.1		
Hardness (mg/L as $CaCO_3$)	920	790	890	810	790	750	800	720	760
Hardness, noncarbonate (mg/L as $CaCO_3$)	410	370							
Calcium, dissolved (mg/L as Ca)	120	100	110	94	100	85	88	75	75
Magnesium, dissolved (mg/L as Mg)	150	130	150	140	130	130	140	130	140
Sodium, dissolved (mg/L as Na)	69	59	66	61	53	56	66	69	85
Sodium adsorption ratio	1	0.9	1	0.9	0.8	0.9	1	1.3	1.6
Percent sodium	14	14	14	14	13	14	15	17	19
Potassium, dissolved (mg/L as K)	8.8	8.5	9.4	10	9.2	9.2	9.1	10	8.7
Chloride, dissolved (mg/L as Cl)	20	14	17	16	13	17	18	17	16
Sulfate, dissolved (mg/L as SO_4)	510	460	570	480	440	430	470	450	460
Fluoride, dissolved (mg/L as F)	0.7	0.5	0.5	0.6	0.5	0.4	0.4	0.4	0.4
Silica, dissolved (mg/L as SiO_2)	15	12	12	13	13	12	14	9.9	11
Arsenic, dissolved (μg/L as As)				2					
Arsenic, suspended total (μg/L as As)				0					
Arsenic, total (μg/L as As)				1					
Boron, dissolved (μg/L as B)	130	110	170	180	150	160	160	160	150
Cadmium, dissolved (μg/L as Cd)				<1					
Cadmium, total recoverable (μg/L as Cd)				0					
Copper, dissolved (μg/L as Cu)				1					
Copper, suspended recoverable (μg/L as Cu)				3					
Copper, total recoverable (μg/L as Cu)				4					
Iron, suspended recoverable (μg/L as Fe)	1,500	330	600	160	140	140	570	170	
Iron, total recoverable (μg/L as Fe)	1,500	350	680	170	160	150	590	180	350
Iron, dissolved (μg/L as Fe)	10	20	80	10	20	10	20	11	<10
Lead, dissolved (μg/L as Pb)				3			1		
Lead, suspended recoverable (μg/L as Pb)				0			1		
Lead, total recoverable (μg/L as Pb)				0			2		
Manganese, suspended recoverable (μg/L as Mn)	40	10	30	10	10	10	30	5	10
Manganese, total recoverable (μg/L as Mn)	70	40	50	30	30	30	50	20	30
Manganese, dissolved (μg/L as Mn)	30	30	20	20	20	20	20	15	17
Molybdenum, dissolved (μg/L as Mo)				<10					
Molybdenum, total recoverable (μg/L as Mo)				2					
Nickel, dissolved (μg/L as Ni)				0					
Nickel, suspended recoverable (μg/L as Ni)				4					
Nickel, total recoverable (μg/L as Ni)				4					
Zinc, dissolved (μg/L as Zn)				10			10		
Zinc, suspended recoverable (μg/L as Zn)				10			20		
Zinc, total recoverable (μg/L as Zn)				20			30		
Aluminum, total recoverable (μg/L as Al)				620			610		
Aluminum, dissolved (μg/L as Al)				0			20		
Aluminum, suspended recoverable (μg/L as Al)				620			590		
Selenium, dissolved (μg/L as Se)				1					
Selenium, suspended total (μg/L as Se)				0					
Selenium, total (μg/L as Se)				1					
Solids, sum of constituents, dissolved (mg/L)	1,200	1,040	1,180	1,080	1,050	992	1,070	1,010	1,060
Solids, dissolved (tons per day)	2.0	1.9	5.1	3.5	5.4	0.72	1.7	1.0	0.69
Solids, dissolved (tons per acre-foot)	1.6	1.4	1.6	1.5	1.4	1.4	1.5	1.4	1.4
Sediment, suspended sieve diameter percent finer than 0.062 mm			79		61				
Nitrogen, ammonia dissolved (mg/L as NH_4)	0								
Mercury, dissolved (μg/L as Hg)				0					
Mercury, suspended recoverable (μg/L as Hg)				0					
Mercury, total recoverable (μg/L as Hg)				0					
Sediment suspended (mg/L)	176	95	179	404	331	27	101	25	35
Sediment, discharge, suspended (tons per day)	0.29	0.17	0.77	1.3	1.7	0.02	0.16	0.03	0.02
Potassium 40, dissolved (pci/L as K40)	6.6	6.3	7.0	7.5	6.9	6.9	6.8		
Specific conductance laboratory (umhos)	1,420	1,480	1,560	1,520	1,490	1,490	1,520	1,460	1,590
Alkalinity laboratory (mg/L as $CaCO_3$)	510	420	410	440	480	420	440	420	430
Hardness, noncarbonate (mg/L as $CaCO_3$)			480	370	310	330	360	300	330

Statistical analysis system
Collom Gulch near Axial, Colo.
Station 401925107523500

Constituent	Number of observations	Mean	Standard deviation	Minimum value	Maximum value	Standard error of mean
Temperature (°C)	8	17.12	5.26	13	29.50	1.86
Streamflow, instantaneous (cfs)	8	.49	.41	0.07	1.40	.15
Specific conductance (umhos)	8	910.25	73.13	744	981	25.85
pH (units)	8	8.31	.11	8.20	8.50	.04
pH laboratory (units)	8	7.93	.07	7.80	8	.03
Nitrogen, NO_2+NO_3 dissolved (mg/L as N)	8	.41	.14	.14	0.58	.05
Phosphorus, total (mg/L as P)	1	.06		.06	.06	
Hardness (mg/L as $CaCO_3$)	8	483.75	30.68	420	520	10.85
Calcium, dissolved (mg/L as Ca)	8	79.50	6.30	68	87	2.23
Magnesium, dissolved (mg/L as Mg)	8	69	9.84	52	85	3.48
Sodium, dissolved (mg/L as Na)	8	26.13	5.96	16	36	2.11
Sodium adsorption ratio	8	.55	.12	0.40	0.80	.04
Percent sodium	8	10.50	1.51	8	13	.53
Potassium, dissolved (mg/L as K)	8	6.20	.72	5.50	7.70	.25
Chloride, dissolved (mg/L as Cl)	8	14.75	3.24	11	20	1.15
Sulfate, dissolved (mg/L as SO_4)	8	197.50	29.64	150	250	10.48
Fluoride, dissolved (mg/L as F)	8	.38	.07	0.30	0.50	.03
Silica, dissolved (mg/L as SiO_2)	8	12.75	1.04	11	14	.37
Arsenic, dissolved (µg/L as As)	1	1		1	1	
Arsenic, total (µg/L as As)	1	2		2	2	
Cadmium, dissolved (µg/L as Cd)	1	1		1	1	
Cadmium, total recoverable (µg/L as Cd)	1	1		1	1	
Chromium, dissolved (µg/L as Cr)	1	1		1	1	
Chromium, total recoverable (µg/L as Cr)	1	3		3	3	
Cobalt, dissolved (µg/L as Co)	1	1		1	1	
Cobalt, total recoverable (µg/L as Co)	1	2		2	2	
Copper, dissolved (µg/L as Cu)	1	2		2	2	
Copper, total recoverable (µg/L as Cu)	1	10		10	10	
Iron, total recoverable (µg/L as Fe)	1	4,500		4,500	4,500	
Iron, dissolved (µg/L as Fe)	1	17		17	17	
Lead, dissolved (µg/L as Pb)	1	2		2	2	
Lead, total recoverable (µg/L as Pb)	1	4		4	4	
Manganese, total recoverable (µg/L as Mn)	1	300		300	300	
Manganese, dissolved (µg/L as Mn)	1	79		79	79	
Zinc, dissolved (µg/L as Zn)	1	8		8	8	
Zinc, total recoverable (µg/L as Zn)	1	40		40	40	
Aluminum, total recoverable (µg/L as Al)	1	3,000		3,000	3,000	
Aluminum, dissolved (µg/L as Al)	1	20		20	20	
Selenium, dissolved (µg/L as Se)	1	3		3	3	
Selenium, total (µg/L as Se)	1	3		3	3	
Solids, sum of constituents, dissolved	8	591.88	46.21	497	641	16.34
Solids, dissolved (tons per day)	8	.75	.54	0.12	1.88	.19
Solids, dissolved (tons per acre-foot)	8	.81	.06	.68	.87	.02
Mercury, dissolved (µg/L as Hg)	1	.10		.10	.10	
Mercury, total recoverable (µg/L as Hg)	1	.10		.10	.10	
Sediment, suspended (mg/L)	1	297		297	297	
Sediment, discharge, suspended (tons/day)	1	1.10		1.10	1.10	
Potassium 40, dissolved (pci/L as K40)	6	4.65	.55	4.20	5.70	.23
Specific conductance lab (umhos)	8	905.25	54.76	783	954	19.36
Alkalinity laboratory (mg/L as $CaCO_3$)	8	305.63	24.70	270	340	8.73
Hardness, noncarbonate (mg/L as $CaCO_3$)	8	177.50	33.70	140	250	11.91

Water quality data
Collom Gulch near Axial, Colo.
Station 401925107523500
Water year October 1980 to September 1981

	Date						
	April 13	April 29	May 13	June 17	July 1	July 16	September 9
Streamflow, instantaneous (cfs)	0.50	0.53	0.62	0.36	0.30	0.16	0.07
Specific conductance (umhos)	902	930	930	901	923	981	971
pH (units)	8.5	8.4	8.4	8.3	8.2	8.2	8.3
Temperature (°C)	14.5	17	14.5	17.5	17	29.5	14
Hardness (mg/L as $CaCO_3$)	470	480	480	490	500	510	520
Hardness, noncarbonate (mg/L as $CaCO_3$)	160	150	180	190	180	170	250
Calcium, dissolved (mg/L as Ca)	87	72	83	83	80	81	68
Magnesium, dissolved (mg/L as Mg)	61	74	66	68	72	74	85
Sodium, dissolved (mg/L as Na)	23	25	24	25	31	29	36
Percent sodium	10	10	10	10	12	11	13
Sodium adsorption ratio	0.5	0.5	0.5	0.5	0.6	0.6	0.8
Potassium, dissolved (mg/L as K)	5.8	7.7	6.5	5.6	6	5.9	6.6
Alkalinity laboratory (mg/L as $CaCO_3$)	310	330	300	300	320	340	270
Sulfate, dissolved (mg/L as SO_4)	170	200	210	200	190	210	250
Chloride, dissolved (mg/L as Cl)	11	15	12	15	17	17	20
Fluoride, dissolved (mg/L as F)	0.4	0.5	0.3	0.4	0.3	0.4	0.4
Silica, dissolved (mg/L as SiO_2)	13	12	11	14	14	13	12
Solids, sum of constituents, dissolved (mg/L)	559	607	595	594	605	637	641
Solids, dissolved (tons per acre-foot)	0.76	0.83	0.81	0.81	0.82	0.87	0.87
Solids, dissolved (tons per day)	.75	.87	1	.58	.49	.28	.12
Nitrogen, NO_2+NO_3, dissolved (mg/L as N)	.36	.58	0.33	.49	.42	.41	.14
Potassium 40, dissolved (pci/L as K40)	4.3	5.7	4.8	4.2	4.5	4.4	

APPENDIX H

GROUND WATER HYDROLOGY

Water Levels and Water Quality in Alluvial Aquifers Near Collom Gulch, Moffat County, Colo.

by
Robert S. Williams, Jr. and Stephen E. Hammond

Prepared in cooperation with the
U.S. Bureau of Land Management

U.S. Geological Survey
Lakewood, Colo.
1983

APPENDIX H

GROUND WATER HYDROLOGY

Abstract

Seven wells were drilled to the base of the alluvium near Collom Gulch, Colo., as part of an environmental evaluation of an area to be leased for coal mining. Water levels were measured twice in the wells. The maximum saturated thickness penetrated by the well was 10.4 feet. Chemical analysis of water samples from two of the wells showed the water to contain mainly calcium, magnesium, bicarbonate, and sulfate ions.

Introduction

The area near Collom Gulch is a potential coal lease site. Hydrology is one of the components of the environment that needs to be evaluated before leasing.

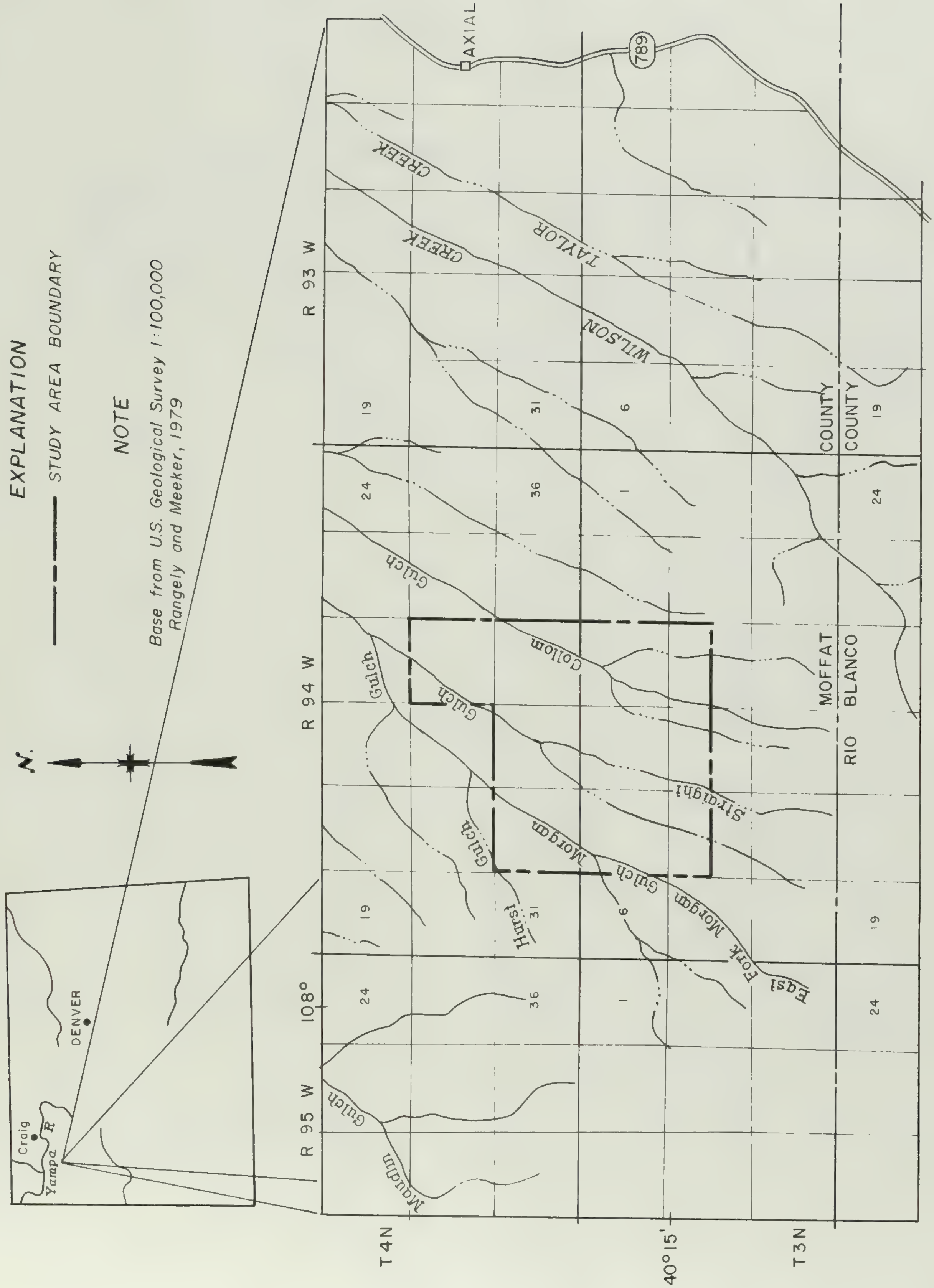
This report gives information on seven alluvial test wells. This study was done in cooperation with the U.S. Bureau of Land Management. Equipment and personnel for drilling were provided by the U.S. Bureau of Reclamation. Samples of the alluvial material were taken for analysis by the U.S. Bureau of Reclamation.

Description of Study Area

The Collom Gulch study area is approximately 35 miles southwest of Craig, Colo., in secs. 3, 4, and 5, T. 3 N., R. 94 W., and in secs. 27, 32, 33, and 34, T. 4 N., R. 94 W. (Figure 1). The topography of the approximately 7-square-mile area is characterized by ridges and valleys. The principal streams are Morgan Gulch, Straight Gulch, and Collom Gulch, which drain to the Yampa River north of the study area. Morgan Gulch, Collom Gulch, and the lower part of Straight Gulch are perennial in the study area. A small holding pond is located in the Morgan Gulch drainage. A few springs are in the study area. The vegetative cover is characterized by grasses, sagebrush, scrub oak, and aspen.

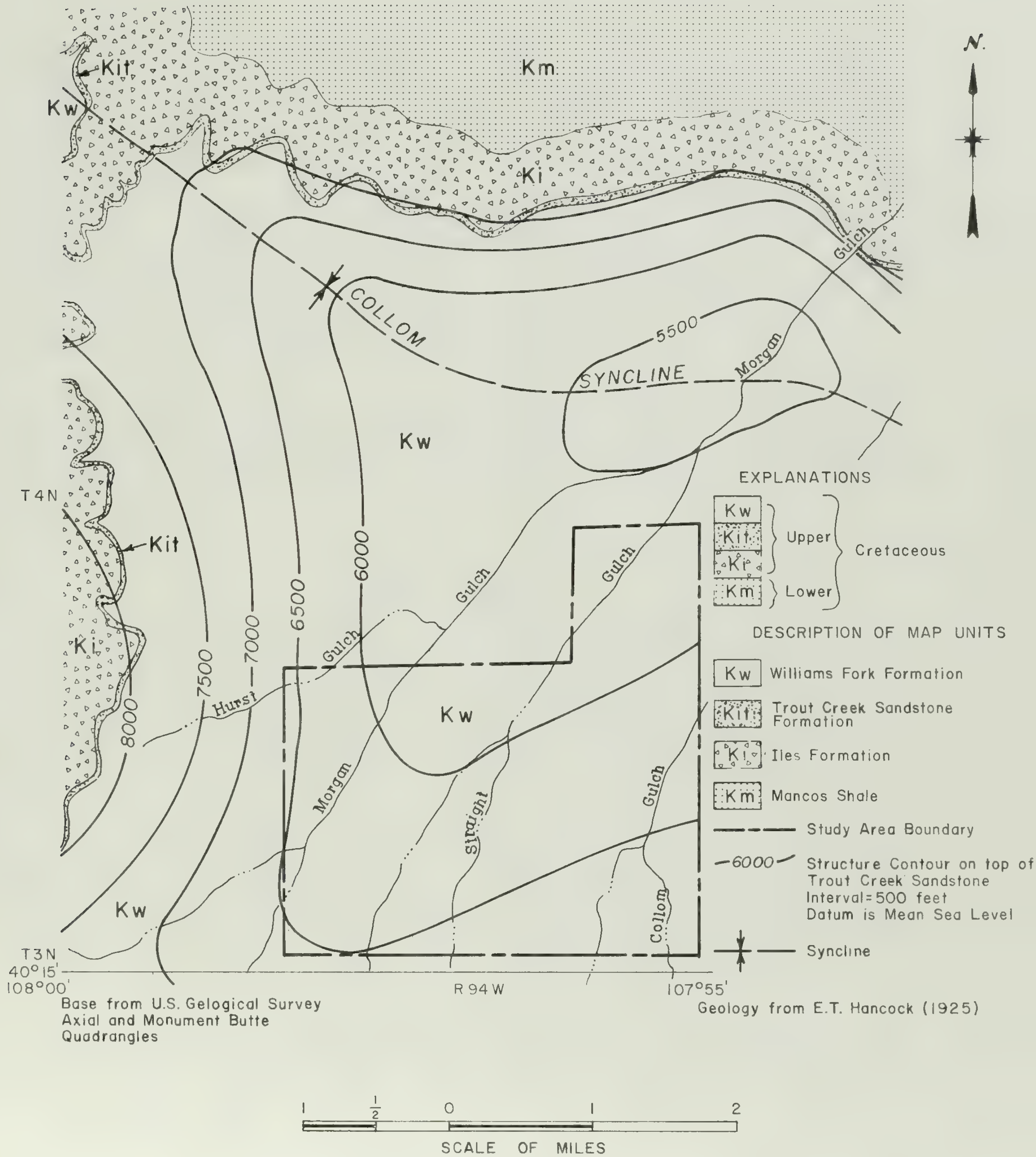
Geology and Structure

A geologic map of the Collom Gulch area is shown in Figure 2. The bedrock formations that crop out in the area are, in ascending order, the Mancos Shale (Upper and Lower Cretaceous), the Iles Formation (Upper Cretaceous), and the Williams Fork Formation (Upper Cretaceous). The



LOCATION AND MAJOR DRAINAGES COLLOM GULCH
STUDY AREA

FIGURE 1



BEDROCK GEOLOGY

THE COLLOM GULCH STUDY AREA
U.S.G.S.

FIGURE 2

Mancos Shale is a grey to dark grey marine shale; it is approximately 3,000 feet thick in the study area (Reheis, 1981). The Mancos Shale is conformably overlain by the Iles Formation (1,000 feet thick). The lower part of the Iles Formation is characterized by alternating beds of thick sandstones, sandy shales, and coal. The Trout Creek Sandstone Member (100 feet thick) is found in the upper part of the Iles Formation. The Iles Formation is overlain by the Williams Fork Formation (500 to 1,500 feet thick), which contains alternating siltstones, sandstones, sandy shales, carbonaceous shales, and coal beds. The Williams Fork and Iles Formations are part of the Mesaverde Group (Hancock, 1925). The Twentymile Sandstone Member of the Williams Fork Formation, an aquifer in many areas, has been removed from the area shown in Figure 2 by erosion that has taken place since uplift during late Cretaceous time.

The bedrock formations in the Collom Gulch study area dip generally northward toward the axis of the Collom syncline. Because the strike of the bedding is perpendicular to the northward-trending ridges and valleys, the stratigraphic sequence described above crops out along the side of the ridges.

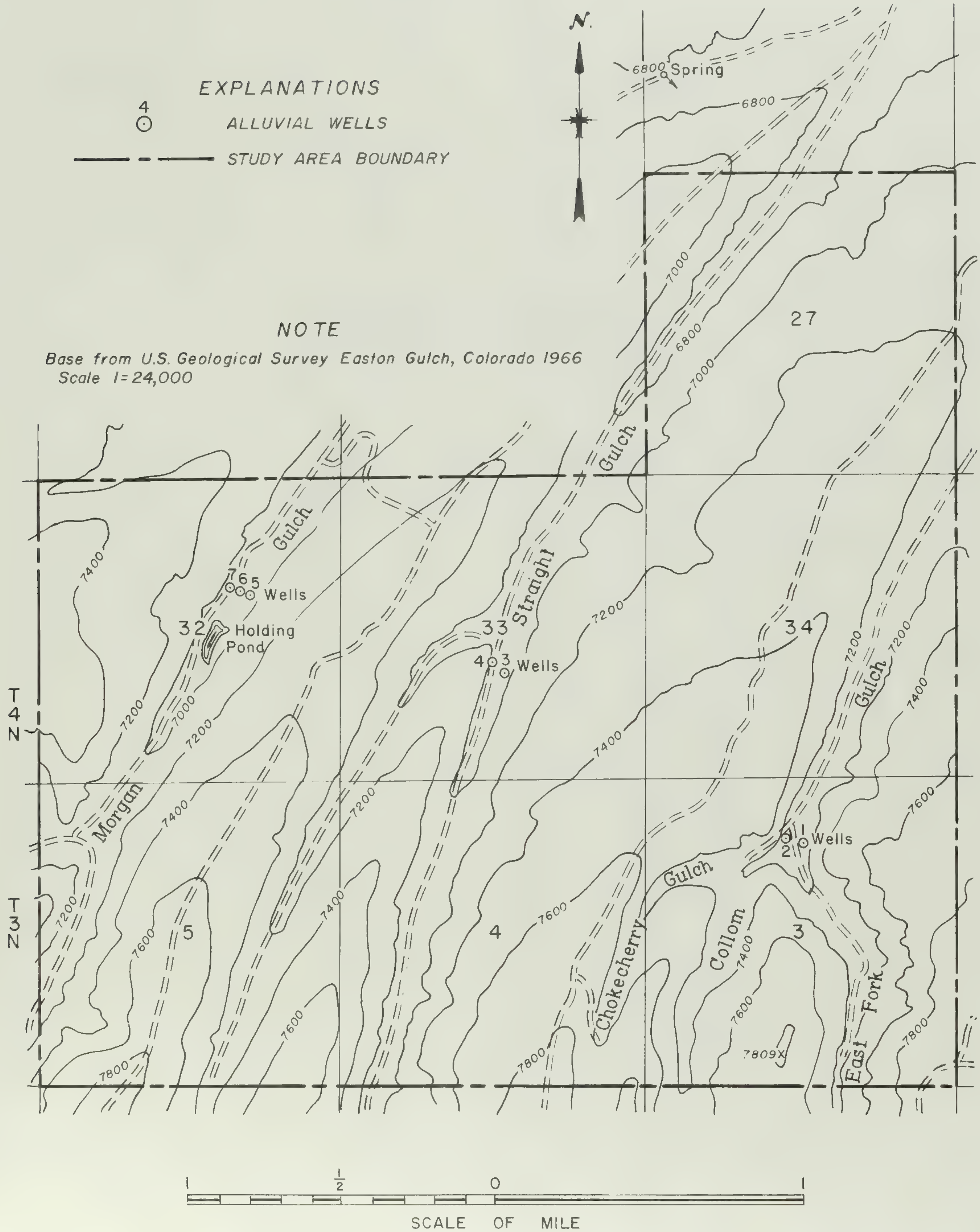
Alluvial Wells

Seven alluvial wells were drilled by the U.S. Bureau of Reclamation using a truck-mounted auger. The auger can drill to a maximum depth of 27 feet. The alluvial wells were located on a line at right angles to the stream channel (Figure 3). Two alluvial wells were drilled in Collom Gulch, two in Straight Gulch, and three in Morgan Gulch. In some parts of the Collom Gulch area, however, the saturated material may be colluvium.

The alluvial wells were completed by placing a 4-inch slotted PVC pipe to the base of the alluvium. A cap was placed at the bottom of the casing to prevent infiltration of the alluvial material. The total depth of the alluvium is not known at alluvial well 2 in Collom Gulch because the depth of the alluvium exceeded the 27-foot-maximum drilling depth of the auger.

No water was found in well 7 in Morgan Gulch on April 2, 1981. Well 1 in Collom Gulch contains less than 1 foot of water. The greatest measured saturated thickness of the alluvium was 10.4 feet in well 3 in Straight Gulch. Additional water level and well information is given in Table 1 on page 227.

The water from well 3 in Straight Gulch and well 6 in Morgan Gulch was analyzed for chemical quality. The concentrations of the various constituents are shown in Tables 2 and 3 on pages 228 and 229, respectively. The ionic composition of the water from both wells is dominated by calcium, magnesium, bicarbonate, and sulfate ions. The composition of the ions is typical of alluvial water associated with many sedimentary deposits in the area.



LOCATION OF ALLUVIAL WELL COLLOM GULCH

STUDY AREA

FIGURE 3

Table 1
Records of alluvial wells and water levels

Well number1/	Location	Zone of completion below land surface2/ (feet)	Type of casing	Altitude at land surface3/ (feet)	Depth to water level below land surface4/ (feet)	Date of water level measurement	Remarks5/
1	Collom Gulch	0-21.93	PVC6/	7,160	21.43	10/9/80	
					20.37	4/2/81	
2	Collom Gulch	0-26.73	PVC	7,160	24.50	10/9/80	
					23.07	4/2/81	
3	Straight Gulch	0-21.13	PVC	6,950	11.12	10/9/80	QW
					10.72	4/2/81	
4	Straight Gulch	0-18.64	PVC	6,950	13.71	10/9/80	
					13.00	4/2/81	
5	Morgan Gulch	0-14.63	PVC	6,960	7.88	10/9/80	
					10.83	4/2/81	
6	Morgan Gulch	0-11.93	PVC	6,960	4.04	10/9/80	QW
					4.83	4/2/81	
7	Morgan Gulch	0-11.93	PVC	6,960	7.43	10/9/80	
					Dry	4/2/81	

1/ See page or section title and Figure 3 for a description of the well numbering system.
2/ Measured depths are given in feet and tenths.
3/ Estimated from topographic map.
4/ Measured depths are given in feet, tenths, and hundredths below the land surface.
5/ Water quality (QW) sample was taken and data are included with this report.
6/ Polyvinyl chloride pipe (PVC).

Table 2
Water quality data for alluvial well 3,
Straight Gulch

Constituents	Reporting units	
Total alkalinity laboratory ($CaCO_3$)	mg/L	510
Dissolved aluminum (Al)	µg/L	0
Dissolved arsenic (As)	µg/L	2
Dissolved bicarbonate (HCO_3)	mg/L	622
Dissolved boron (B)	µg/L	140
Dissolved cadmium (Cd)	µg/L	1
Dissolved calcium (Ca)	mg/L	230
Dissolved chloride (Cl)	mg/L	37
Dissolved copper (Cu)	µg/L	2
Dissolved fluoride (F)	mg/L	0.4
Hardness ($CaCO_3$)	mg/L	1,400
Noncarbonate hardness ($CaCO_3$)	mg/L	850
Dissolved iron (Fe)	µg/L	40
Dissolved lead (Pb)	µg/L	2
Dissolved magnesium (Mg)	mg/L	190
Dissolved manganese (Mn)	µg/L	380
Dissolved mercury (Hg)	µg/L	0
Dissolved molybdenum (Mo)	µg/L	10
Dissolved nickel (Ni)	µg/L	2
NO_2 + NO_3 dissolved nitrogen (N)	mg/L	6.7
Field pH	units	7.5
Dissolved orthophosphorous (P)	mg/L	0
Dissolved potassium (K)	mg/L	9.1
Calculated sum of dissolved solids1/	mg/L	1,750
Dissolved selenium (Se)	µg/L	26
Dissolved silica (SiO_2)	mg/L	14
Sodium adsorption ratio2/		0.7
Dissolved sodium (Na)	mg/L	55
Percent sodium3/	%	8
Laboratory specific conductance	umhos	2,100
Dissolved sulfate (SO_4)	mg/L	880
Dissolved vanadium (V)	µg/L	4
Water temperature	°C	9
Dissolved zinc (Zn)	µg/L	30

Explanatory notes: Station ID number: 401618107563402, Straight Gulch, Moffat County, Colo.
Date of collection: July 29, 1981.
mg/L = milligrams per liter.
µg/L = micrograms per liter.
Units = hydrogen ion activity in logarithmic units.
Time of collection: 1347.
me/L = milliequivalents per liter.
umhos = micromhos per centimeter at 25° Celsius.
°C = degrees Celsius.

1/ mg/L CO_3^{-2} = mg/L (ALK.) $CaCO_3$ x 0.60, $\sum$mg/L (CO_3^{-2} + Ca + Mg + Na + K + Cl + SO_4 + SiO_2)

2/ $$\frac{\text{me/L Na}}{\sqrt{\frac{\text{me/L Ca + me/L mg}}{2}}}$$

3/ $$\frac{\text{me/L Na}}{\sum \text{me/L (Na + K + Ca + Mg)}} \times 100$$

Table 3
Water quality data for alluvial well 6,
Morgan Gulch

Constituents	Reporting units	
Total alkalinity laboratory ($CaCO_3$)	mg/L	490
Dissolved aluminum (Al)	µg/L	0
Dissolved arsenic (As)	µg/L	2
Dissolved bicarbonate (HCO_3)	mg/L	598
Dissolved boron (B)	µg/L	270
Dissolved cadmium (Cd)	µg/L	<1
Dissolved calcium (Ca)	mg/L	139
Dissolved chloride (Cl)	mg/L	17
Dissolved copper (Cu)	µg/L	5
Dissolved fluoride (F)	mg/L	0.5
Hardness ($CaCO_3$)	mg/L	920
Noncarbonate hardness ($CaCO_3$)	mg/L	430
Dissolved iron (Fe)	µg/L	35
Dissolved lead (Pb)	µg/L	2
Dissolved magnesium (Mg)	mg/L	140
Dissolved manganese (Mn)	µg/L	620
Dissolved mercury (Hg)	µg/L	0
Dissolved molybdenum (Mo)	µg/L	<10
Dissolved nickel (Ni)	µg/L	0.5
$NO_2 + NO_3$ dissolved nitrogen (N)	mg/L	.13
Field pH	units	7.3
Dissolved orthophosphorus (P)	mg/L	.05
Dissolved potassium (K)	mg/L	7.2
Calculated sum dissolved solids1/	mg/L	1,150
Dissolved selenium (Se)	µg/L	0
Dissolved silica (SiO_2)	mg/L	14
Sodium adsorption ratio2/		0.7
Dissolved sodium (Na)	mg/L	40
Percent sodium3/	%	9
Laboratory specific conductance	umhos	1,540
Dissolved sulfate (SO_4)	mg/L	500
Dissolved vanadium (V)	µg/L	7
Water temperature	°C	14
Dissolved zinc (Zn)	µg/L	7

Explanatory notes: Station ID number: 401629107573001, Morgan Gulch, Moffat County, Colo.
Date of collection: July 29, 1981.
mg/L = milligrams per liter.
µg/L = micrograms per liter.
Units = hydrogen ion activity in logarithmic units.
Time of collection: 1210
me/L = milliequivalents per liter.
umhos = micromhos.
°C = degrees Celsius.

1/ mg/L CO_3^{-2} = mg/L (ALK.) $CaCO_3 \times 0.60$, $\sum$mg/L (CO_3^{-2} + Ca + Mg + Na + K + Cl + SO_4 + SiO_2)

2/ $$\frac{\text{me/L Na}}{\sqrt{\frac{\text{me/L Ca + me/L mg}}{2}}}$$

3/ $$\frac{\text{me/L Na}}{\sum \text{me/L (Na + K + Ca + Mg)}} \times 100$$

Summary and Conclusions

The alluvium in the area is partly saturated. The saturated thickness of the alluvium penetrated by seven test wells is 10.4 feet. The dominant ions in the alluvial water are calcium, magnesium, bicarbonate, and sulfate. The chemistry of the water samples taken from the alluvium is typical of the water from alluvial aquifers associated with sedimentary deposits in the area.

REFERENCES

1. Hancock, E. T., 1925, Geology and Coal Resources of the Axial and Monument Butte Quadrangles, Moffat County, Colo., U.S. Geological Survey Bulletin 757, 134 pages.

2. Reheis, M. C., 1981, Geologic Map and Coal Resources of the Easton Gulch Quadrangle, Moffat County, Colo., U.S. Geological Survey Coal Investigations Map C-87.

METRIC CONVERSION FACTORS

Inch-pound units used in this report may be converted to metric units by the following conversion factors.

Multiply inch-pound unit	By	To obtain metric unit
foot (ft)	0.3048	meter
mile (mi)	1.609	kilometer
square mile (mi^2)	2.590	square kilometer

National Geodetic Vertical Datum of 1929 (NGVD of 1929): A geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called mean sea level. NGVD of 1929 is referred to as sea level in this report.